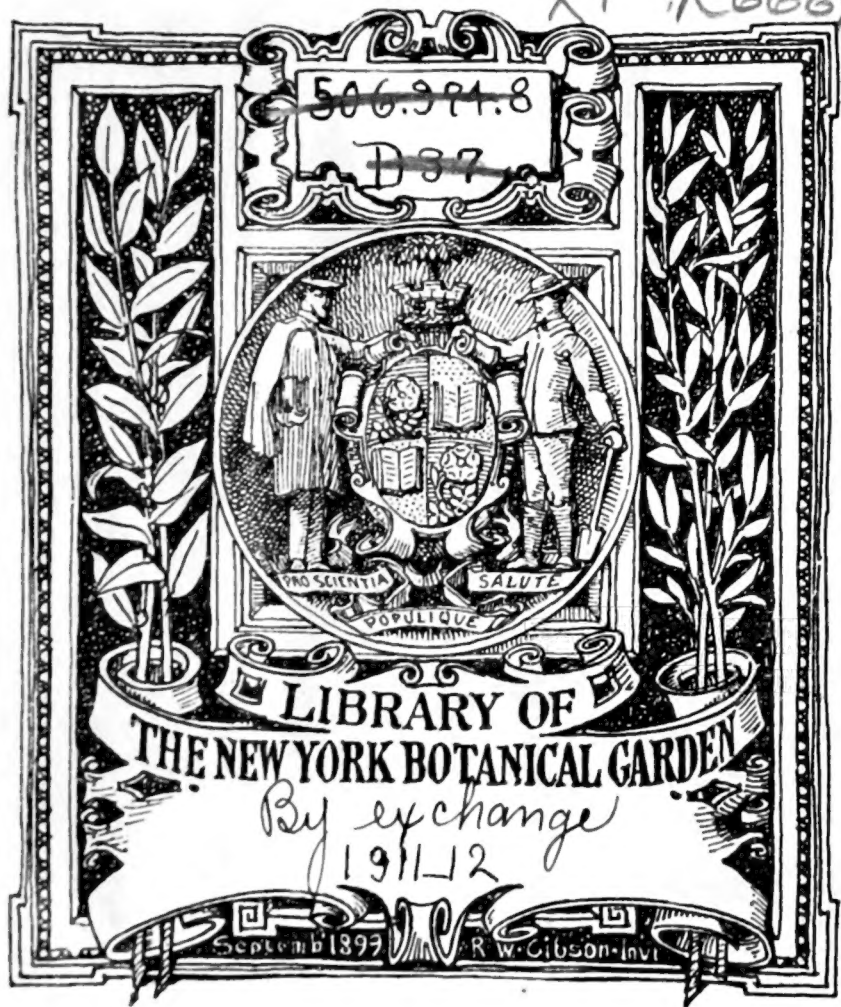
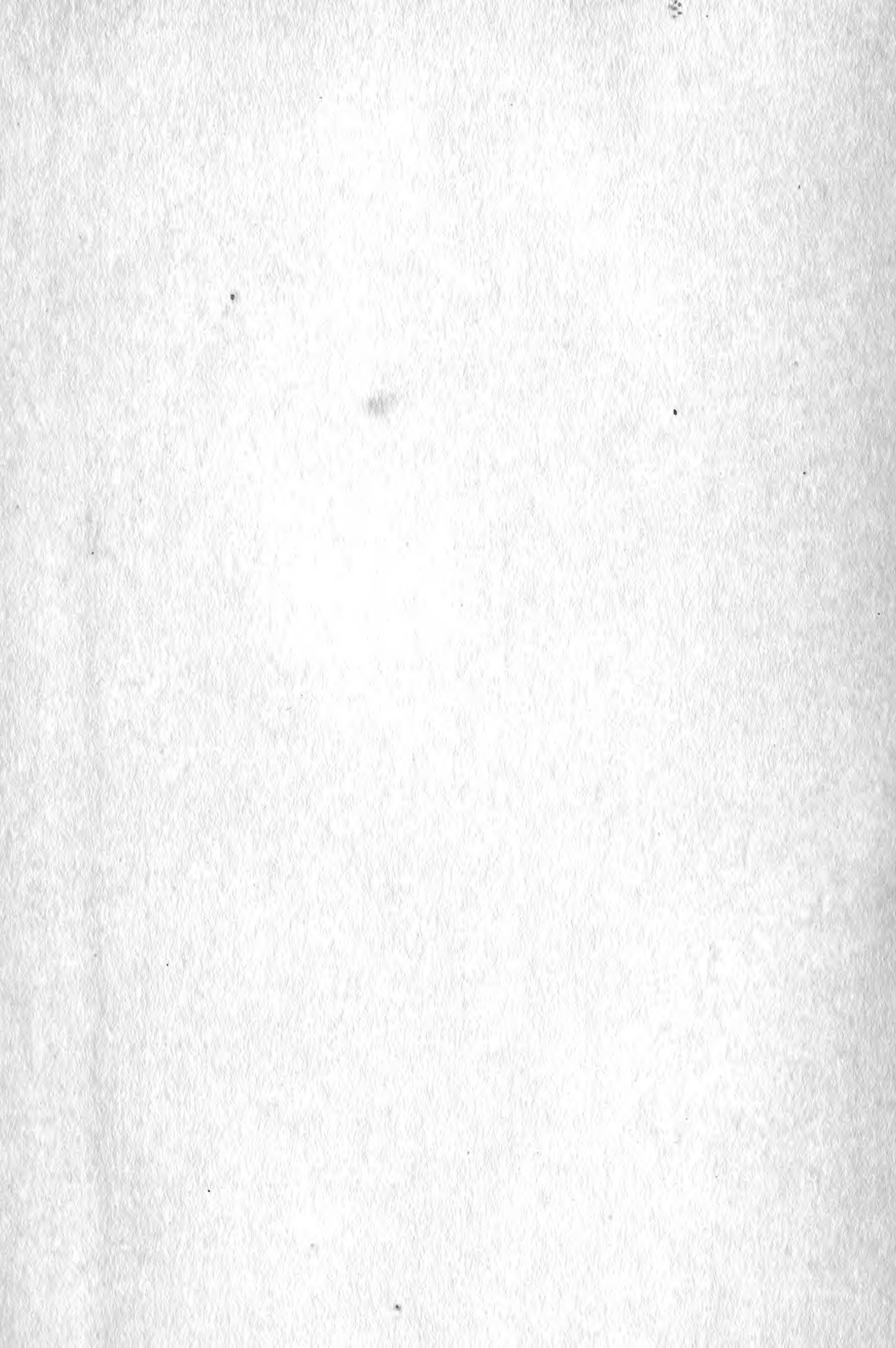


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PROCEEDINGS

OF THE

Delaware County Institute of Science

Carolus M. Broomall, Editor

PUBLICATION COMMITTEE:

T. Chalkley Palmer, Chairman; Trimble Pratt, M. D.,
J. C. Starbuck, M. D., B. M. Underhill, V. M. D.

Volume VI: October, 1910, to July, 1911

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Vol. VI, No. 1

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. VI, No. 1

OCTOBER, 1910

THE FLOOD OF 1843.

In the year 1843 there occurred in this neighborhood one of the most remarkable phenomena of which local history gives an account. "The Flood of 1843" is considered by those who remember it as one of the mile-stones of Delaware County history. So extraordinary was this flood and so great the damage done, that shortly after the occurrence a committee of the Delaware County Institute of Science was appointed to investigate and make report in regard to it. The members of this committee were Dr. George Smith, John P. Crozer and Minshall Painter. A number of copies of the report of this committee were printed for private circulation, but very few of these copies are now in existence. In response to the frequent inquiries that have been made for data concerning the Flood of 1843, it has been deemed advisable to reprint the report in full in these PROCEEDINGS.

REPORT.

An event of such an extraordinary character as the storm of rain and consequent inundation with which the county of Delaware was visited on the 5th of August, 1843, accompanied as it was with so many circumstances which the past experience of the inhabitants of the county had not taught them to anticipate—an event which in point of magnitude and dreadful consequence, many ages had passed by without witnessing, and which in all probability may not be again witnessed for many ages yet to come, certainly deserves to be inquired into with the greatest possible care, and to have all the accompanying facts, embodied in such a manner as to

give some probability that they may be transmitted to future generations so as to be understood and to be relied upon for their accuracy. Understanding this to be the primary object of the Institute, the Committee have exerted themselves individually to the utmost extent that their leisure would permit, in collecting the materials necessary to bring about so desirable a result; and they have also availed themselves of the aid of a considerable number of their fellow-citizens, selected as well for their general intelligence, as from the circumstance of their occupying positions which necessarily rendered them familiar with many important or interesting facts connected with the subject under examination. Circulars were addressed to more than forty gentlemen, embracing inquiries on the following points, viz.:

1st. The time of the commencement and termination of the heavy rain.

2nd. The direction of the wind at different periods of time during the day—its violence, and the time of its greatest violence.

3rd. The quantity of rain which fell at a particular place, (if ascertained with any degree of accuracy.)

4th. The greatest height of the flood above the usual level of the water in the several creeks, and the time at which the water was at its greatest height.

5th. An account of the damage done to bridges, manufactories, mills, mill-dams, dwellings, &c.; together with an estimate of the loss sustained by the County, and by individuals, in consequence of the destruction or damage done to their property. The loss occasioned by the destruction of crops, fences, etc.

6th. The number of lives lost; the names and ages of the individuals, and the particulars connected with their loss: also any facts connected with the rescue of persons from drowning who were in imminent danger.

7th. Any facts evincing the power of rapid currents of water in transporting earth, sand, rocks, and other materials.

8th. Any other facts which may be considered important or interesting.

From a number of the gentlemen to whom these circulars were addressed, very satisfactory replies have been received; from which, and from the personal examinations of the committee, the following details have been made out: As voluminous as these details may appear, it is highly probable that many interesting particulars may not have come to the knowledge of the committee. They feel free, however, to state, that so far as they have undertaken to give facts and estimates, they have very great confidence in their general accuracy.

A meteorological phenomenon so unique in its character as the storm of the fifth of August, together with the almost instantaneous rise in the waters of several large streams with their numerous tributaries, could hardly fail to give rise to a number of philosophical problems not very easy of solution by persons unaccustomed to such investigations. On this account it has been a source of regret to the committee, that the subject had not been confided to hands more skillful and experienced in such matters. In the few explanations, however, which they have attempted of any subject which presented to their minds the least difficulty or doubt, they have been careful to give *all* the facts which to them appeared at all relevant, so that the correctness of their conclusions can be readily tested by others.

TOPOGRAPHICAL VIEW OF DELAWARE COUNTY.

Before proceeding to detail the results of their examinations and inquiries, the committee have considered that it would not be amiss to present a brief topographical sketch of the county, drawn particularly with a view of illustrating the subject under examination.

In point of territory, Delaware county is the smallest

county in Pennsylvania, except Philadelphia. It is bounded by Philadelphia county on the east; by Montgomery on the north-east; on the north-west by Chester county, and on the south by the state of Delaware and Delaware river. It contains about 177 square miles.

The county is principally drained by five large creeks, four of which, viz.: Chester, Ridley, Crum and Darby creeks, are mill streams, before they enter the county. These streams have a general course, a little east of south, and after traversing the whole breadth of the county, empty into the Delaware. The only material variation from this general course is in Darby creek, after it reaches the head of tide; from which point it has a southerly and southwesterly meandering course of about nine miles before it reaches the Delaware.

Cobb's creek rises in the township of Haverford, and after crossing the southern border of that township, it forms the boundary line between this county and Philadelphia to the point where it empties into Darby creek, a short distance below the head of tide water.

The *Brandywine* forms a part of the western boundary of the county.

Chester creek enters the county by two principal branches designated "East" and "West." These are both good mill streams, and after their junction at Crozerville, form the largest of the creeks above named, except the Brandywine. This creek unites its water with the Delaware river, at the borough of Chester.

Darby creek, the next in point of size, also has its origin in two principal branches, which may be distinguished by the terms "East" and "West." These branches unite at the flour mill of Levi Lewis, in Radnor township, and after the united stream has received Ithen creek, it reaches the head of tide, at the village of Darby. *Crum* and *Ridley* creeks are each large streams before they enter Delaware county. They pursue the same general course, and scarcely at a distance of more than two miles from each other. At one point

they approach each other within about half a mile, but afterward diverge and enter the Delaware river by separate mouths, a short distance above Chester.

Besides these there may be enumerated the *Gulf creek*, which has an easterly or north-easterly course and empties into the Schuylkill river a few miles below Norristown, in the county of Montgomery. *Naaman's creek*, which empties into the Delaware river, below Marcus Hook, and within the borders of the State of Delaware; *Hook creek*, which empties into the Delaware at Marcus Hook; *Little Crum creek*, which empties into Crum creek near the Delaware; *Ithen creek* and *Mucanipates*, branches of Darby creek; *Naylor's run*, a branch of Cobb's creek; *Green's run* and *Dismal run*, branches of Ridley creek; *Green's creek*, a branch of Chester creek; *Beaver* and *Valley creeks*, branches of the Brandywine, besides many other streams of a sufficient size to be employed in propelling machinery.

Leaving out of view the meadow lands bordering on the Delaware river, the face of the country is generally undulating and in some parts hilly; and with the exception of a small part of the township of Radnor, which is drained by the Gulf creek, it has a general slope towards the Delaware river. This slope, though *general*, is not entirely *gradual*. There may be particularly observed a sudden elevation in the land extending in a transverse direction to the streams across the whole extent of the county. This sudden elevation in the land, or "water shade," as it has been termed, is at a distance of from three to five miles from the meadows, and nearly parallel to the Delaware. Although in the beds of the several streams, this abrupt rise in the land is in a manner obliterated, yet it nevertheless gives rise to numerous water powers very contiguous to each other. As the creeks are large, and closely approached by the hills at these rapids, and the water powers chiefly occupied on an extensive scale, all the conditions were present to render the flood powerful and destructive. This is fully attested by the result in these par-

ticular localities. The principal creeks mentioned, have a rapid descent from their several sources to the head of tide. William H. Wilson, Esq., of Haverford, has politely furnished the committee with the following, as a very close approximation to the elevation of the sources of the principal streams above tide water, as ascertained by him while engaged on the survey of the Columbia rail road, viz. :

Source of Cobb's creek, 392 feet above tide.

"	Ithen	"	399	"
"	Darby	"	440	"
"	Crum	"	520	"
"	Ridley	"	520	"

The elevation of the source of Chester creek was not ascertained with the same degree of accuracy, but that of its east branch probably exceeds Crum or Ridley creeks.

A large proportion of this fall, particularly within the borders of Delaware county, had been turned to account in propelling mills and manufactories of various kinds, so that previously to the inundation there could have been enumerated within the county

28 Cotton Manufactories ;

15 Woolen Manufactories ;

32 Flour Mills ;

45 Saw Mills ;

8 Paper Mills, and

10 Mills for various purposes, exclusive of those used for cleaning clover seed and grinding plaister.

These establishments necessarily gave rise to a variety of other improvements on the margin of the several streams, and in many instances, within the scope of the inundation.

Delaware county had also become celebrated for the number and substantial character of her bridges. Bridges had been erected on all the main leading highways where they cross the several creeks, and many bridges had also been erected on the less frequented roads. Previously to the inundation there could have been enumerated 45 bridges which

had been erected at the expense of the county. Of these
19 were stone arch bridges ;

4 Lattice do.

1 Chain do.

21 Wooden bridges of different constructions,
besides three stone arch bridges, and one lattice bridge, built
at the joint expense of this county and the county of Philadelphia ; two wooden bridges built in conjunction with Chester county.

Bridges over the smaller streams, which are not included
in the foregoing enumeration, were erected at the expense of
the several townships.

Exclusively of the alluvial meadows, bordering on the
river, but a small part of the soil of Delaware county is nat-
urally of a very superior quality. But its manufacturing
population, and its proximity to a large city, afford such a
certain market for its surplus agricultural produce, that the
farmers have for many years turned their attention to its
improvement, by means of the application of lime and other
manures, so that in point of productiveness, Delaware county
is not now surpassed by any other county in the Com-
monwealth.

The flats bordering on the creeks are mostly cultivated—
in the vicinity of manufacturing establishments they were fre-
quently occupied as gardens by the operatives.

It will be apparent, from the foregoing hasty sketch, that
scarcely any country district of the same extent could be
found where a similar visitation would have been attended
with such disastrous consequences.

THE STORM.

The morning of the 5th of August, at early dawn, gave
indications of a rainy day. The wind was in the east, or

north east, and the clouds were observed to have the appearance which indicated a fall of rain. The sun was barely visible at rising, but in a very short time afterwards the whole sky became overclouded. At about seven o'clock, A. M. it commenced raining, and continued to rain moderately, with occasional remissions, but without any very perfect intermission until noon, or later. This was a general rain, which extended much beyond the limits of Delaware county in every direction. Up to twelve o'clock, M. but one half inch of rain had fallen, as accurately measured by Dr. J. W. Ash, of Upper Darby; and up to the commencement of the great rain storm, it is not probable that more than three-fourths of an inch had fallen in any part of the county. This general rain scarcely caused an appreciable rise in the streams, but it had the effect of fully saturating the surface of the ground with water, to the depth of some inches, and in this way contributed to increase the flood in some degree, beyond what it would have been, had the subsequent *heavy rain* fallen on the parched earth. The air was cool for the season, and the general rain now spoken of, had very much the appearance of a regular easterly storm, with the exception, perhaps, that the clouds wore a more lowering appearance.

No general description of the *heavy rain* which followed, and which caused the inundation, will exactly apply to any two neighborhoods—much less to the whole extent of the county. In the time of its commencement and termination—in the quantity of rain which fell—in the violence and direction of the wind, there was a remarkable want of correspondence between different parts of the county. It may be observed, however, that comparatively little rain fell along its southern and south-eastern borders.

It will hereafter appear, that Cobb's creek, on the eastern margin of the county, and the Brandywine on the west, were not flooded in any very extraordinary degree, so that it will be evident that the greatest violence of the storm was expended on the district of country which is drained by

Chester, Ridley, Crum, Darby, one or two tributaries of the Brandywine, and the Gulf creeks. This district will embrace a part of Chester county, and a small part of Montgomery, but including these, the whole extent of country which was inundated will not exceed in area the territory embraced within the county of Delaware. The extent of territory which was inundated, was also much greater than that which was subjected to any very extraordinary fall of rain. The amount of rain which fell on that part of the county which borders on the Delaware river, and embraces the mouths and lower parts of the inundated creeks, was not sufficient to produce even an ordinary rise in the streams, and to this circumstance may in part be attributed the very unprepared state in which the inhabitants of this district were found for the mighty flood of waters which was approaching to overwhelm them. The very rapid rise in the water, without apparently any adequate cause, was also well calculated to increase the alarm in this district much beyond what it would have been, had the quantity of rain which fell, borne a comparison with that which fell in the upper parts of the county.

As a general rule, the heavy rain occurred later, as we proceed from the sources of the streams toward their mouths. The quantity of rain which fell will also decrease as we proceed in the same direction, particularly from the middle parts of the county downwards.

In those sections of the county where its greatest violence was expended, the character of the storm more nearly accorded with that of a tropical hurricane, than with anything which appertained to this region of country. The clouds wore an unusually dark and lowering appearance, of which the whole atmosphere appeared in some degree to partake, which circumstance, no doubt, gave that peculiarly vivid appearance to the incessant flashes of lightning which was observed by every one. The peals of thunder were loud and almost continuous. The clouds appeared to approach from different directions, and to concentrate at a point not very distant from

the zenith of the beholder. In many places there was but very little wind, the rain appearing to fall in nearly perpendicular streams; at other places it blew a stiff breeze, first from the east or north-east; and suddenly shifting to the south-west; while at a few points it blew in sudden gusts with great violence, accompanied with whirlwinds, which twisted off and prostrated large trees, and swept every thing before it.

So varied, indeed, was the character of the storm at different places, that it would be exceedingly difficult to present any very satisfactory account of it, except by embodying the remarks of different observers at different places. The committee have therefore adopted that course.

As observed by the Hon. Henry Myers, of Concord township, the *heavy rain* commenced at about a quarter to three o'clock, P. M., in that neighborhood—the wind about E. S. E., but it veered so rapidly retrograde to the sun's motion, that the clouds appeared to verge to a centre over the western section of Delaware county, from several points of the compass at the same time—the rain falling in torrents resembling a water spout. At about a quarter to 4 o'clock the wind had nearly boxed the compass, and blew a gale from W. S. W., and about that hour a tornado, or whirlwind, passed across the southern part of Concord, about a quarter of a mile in width, prostrating forest and fruit trees, and scattering the fences in every direction. In the neighborhood of Concord, the rain continued about three hours, and the quantity of rain which fell in that vicinity, as nearly as ascertained, was about sixteen inches.

Judging from the rise in the waters of the West branch of Chester creek, which drains this particular district of country, it is probable that the quantity of rain which fell in this vicinity, equalled, if it did not exceed, that of any other district in the county.

As observed by Mr. Adam B. Williamson, of Newtown township, the heavy rain commenced about two o'clock, and

terminated about five o'clock, P. M.—the wind, during the rain, nearly N. W. There was a heavy blow of wind, but not violent. The quantity of rain which fell, was between 11 and 13 inches. At Newtown Square, in forty minutes immediately before five o'clock, it was ascertained that five and a half inches of rain fell.

As observed by Mr. George Palmer, residing in the northern part of Radnor township, the heavy rain commenced about 4 o'clock, P. M. and terminated at about 6 o'clock. At the commencement of the heavy rain the wind blew from the S. or S. W. but changed to the S. E. about four and a half or five o'clock, from which direction came the heaviest rain. The wind did not blow with violence.

As observed by a member of the committee, at his residence in Crozerville, the storm appeared to have concentrated at that place, and spent itself with awful force. The morning had been lowering with occasional showers of rain—the air rather cool for the season. After noon the sky was thickly overcast, and clouds floated slowly in various directions; the wind, as noted by a weather vane, N. E. After two o'clock, thunder was heard at a distance, which soon became louder and more frequent. About 3 o'clock under an unusually dark sky, rain commenced falling in torrents, accompanied with vivid lightning, and almost continuous peals of thunder. The lightning was more vivid than ever before witnessed by him in the day time, nor had he ever before heard so much loud thunder at one time. The heavy rain terminated a few minutes before 6 o'clock. Crozerville lies in a basin surrounded by steep acclivities. In every direction from these hills, sheets of water poured down, and mingling with the swollen current below, presented, together with the rapid succession of forked lightning, a scene of awful sublimity.

As observed at the residence of Enos Painter, in Middletown, the greatest violence of the rain storm lasted from 3 till 5 o'clock, P. M.—the wind blowing from every quarter during the storm. It did not blow with very great violence,

though a few trees and some fences were blown down, and much of the corn prostrated. The amount of rain which fell was not ascertained, but it was undoubtedly the heaviest rain which had occurred at that place during the recollection of any person living.

As observed at Edward Lewis' mills, in Middletown, the heavy rain commenced between three and four o'clock, and ceased about five P. M.—the wind changeable all the afternoon, but at no time violent.

As observed at Samuel Bancroft's, in Nether Providence, the heavy rain commenced a quarter before 5 o'clock, and continued till a quarter past 6—the wind blowing from the East and S. West.

At the residence of Richard T. Worrall, in Nether Providence, the wind was easterly till about 4 o'clock, when it suddenly shifted to the S. W. at which time the heavy rain commenced and continued till five, or perhaps half past five o'clock. At about five o'clock, the wind blew from W.N.W., and with great violence.

As observed by John C. Beatty, at his residence in the N. W. corner of the township of Springfield, the heavy rain commenced between two and three o'clock in the afternoon, and continued till about five o'clock. The wind blew, but not violently, at his mills. There appeared to be a current of air, or whirlwind, that passed just above on the hill, which broke off trees and took some up by the roots.

Lower down on the same creek with Mr. Beatty, it was remarked by Messrs. John & George Lewis, that in the direction of the wind, (although at no time violent) there was a circumstance very unusual. After it had been raining for some time, there appeared to be two storms of rain approaching at once—one from the S. E. the other from the N. W., which appeared to meet about north from their place, and they could not tell for some minutes which would prevail, but eventually the one from the S. E. carried the sway. There was a considerable increase of rain during the struggle, or

soon after, but nothing at their mills to justify the height of the water which occurred.

As observed by Joel Evans, at his residence in Springfield, and about a mile north from the Messrs. Lewis' but on much higher ground, the heaviest rain fell between five and six o'clock. The direction of the wind during the day, until the heavy fall of rain commenced, being generally from the S. E., though at some periods throughout the day it was variable, shifting from E. S. E., to S. S. E. The atmosphere at a considerable height above the earth's surface, appeared to be in a very unsettled and agitated state, from 12 o'clock, M. to 5 o'clock P. M., which was indicated by contrary and opposite currents of wind prevailing, carrying with them light clouds, which he observed several times in the afternoon; he being induced to go out to make observations on the state of the weather, from its very unusual and threatening appearance. During the fall of the very heavy rain, and as nearly as he can recollect, about half past five o'clock, the wind suddenly commenced blowing with great force from the east, which soon increased to a violent gale, prostrating fences, and some trees in its course. Its velocity was such that with the immense quantity of water falling (which it carried with it in one continuous sheet, as it were), rendered it impossible to see a distance of more than fifty yards. After blowing in this way for fifteen or twenty minutes, the wind almost as suddenly veered to S. W. (nearly the opposite point of the compass,) and for a short time (perhaps not more than from five to ten minutes) blew with equal violence, leveling in that direction on his farm, a number of pannels of fence, and one or two apple trees. The wind subsided about six o'clock, or very soon after, and was succeeded by a calm.

As observed by Professor John F. Frazer, of Philadelphia, who happened to be at the farm of Samuel West, in the upper end of Chester township, the heavy rain commenced late in the afternoon, about half past five or six o'clock, and continued perhaps half an hour or more. During the rain

there was no wind, the streams (for it fell more in streams than in drops) were, apparently quite vertical. Professor F. was unprepared to measure the quantity of rain which fell, but it exceeded any thing which he had ever witnessed. From well authenticated information, which he received from the farm of Mrs. Grubb, in Brandywine Hundred, near the State line, he is perfectly satisfied that the fall of rain at that place exceeded ten inches in about two hours. The rain was much ear ier at Mrs. Grubb's farm than at Mr. West's, commencing there about two o'clock.

In the township of Bethel, not far from the line of the State of Delaware, a hurricane of great violence occurred about four or five o'clock in the afternoon. The wind blew from different points at different places in the same neighborhood, as is manifest from the position of uprooted trees, &c. A peach orchard belonging to Mr. Clayton, was blown down—the trees laying to the N. E. An apple orchard not very distant, lays prostrated toward the South East. At John Larkin's, two miles north of Clayton's, the gale appears to have been most violent. The wind came from the south east, and tore up a large quantity of heavy timber (said to be about two hundred cords) all in a narrow strip, not more than two hundred yards in width. A valley of woodland, bounded by pretty high hills, had nearly all of its timber blown down, and what is very remarkable, the trees are not generally laid lengthwise of the valley, but across it, with their tops towards the north-east, while on the adjacent hills but few trees were uprooted—one very large white oak, however, which was deeply and strongly rooted in a clay soil, was blown down.

At a neighbour's, opposite to Mr. Larkin's, the wind blew from the south, laying several apple-trees due north. The gale left few if any traces, except in one neighborhood—say within the compass of three square miles. Indeed it does not appear to have been severe, except on a few detached farms. The above observations were communicated by John Keenan, who resides in that vicinity.

As observed by another member of the committee at the Hall of the Institute, and on his road from that place to his residence in Upper Darby, the commencement of the heavy rain was about half past three o'clock, with the wind blowing from an easterly direction. At about a quarter before four o'clock, and while the rain was pouring down in torrents, the wind suddenly shifted round to the west, or south west, and remained in that quarter until he arrived at home about five o'clock. The rain was not constantly violent. It would at times slack off for a very few minutes, and then commence again with redoubled violence. There appeared to be so much commotion in the clouds, as to render it difficult to determine from what quarter they came, but the manner in which the rain fell, impressed him forcibly with the idea at the time, that it proceeded from a rapid succession of gusts of fearful violence. The dark and lowering appearance of the clouds was very remarkable, and the rain continued to fall until about six o'clock, about which time, or later, the wind veered round to the S. E. but it did not blow with much force at any time.

It was observed by Dr. Joshua W. Ash, at his residence in Upper Darby, that at about three o'clock P. M. it began to rain heavily, and for the space of more than three hours, a succession of heavy showers occurred, marked by an unusual darkness of the atmosphere, and an unusual heaviness of the drifting clouds, which were at times observed to drag upon the tree tops. These appearances grew more marked as time wore on, until near 7 o'clock, when the clouds which had had a general direction from S. W. to N. E. now gave signs of much atmospheric commotion, crossing each other at irregular and opposite angles; but the prevailing direction appeared to be from the South and West—the wind suddenly shifting from S. W. to East and N. E., where it remained some minutes, and then suddenly wheeled round again to the S. W.

The residence of Dr. Ash is south-east of the district on

which the very unusual rain fell. As accurately measured by him, but three and three-quarter inches fell during the day. Near 7 o'clock, one inch of this quantity fell in the short space of fifteen minutes.

As observed by Dr. Caleb Ash, of Darby, the heavy rain commenced about half past five o'clock, and lasted till seven, P. M. The direction of the wind at different periods of time during the day, varied from N. E. by E. to S. E., but at the time of the heavy rain it was S. West. It did not blow with violence, but was a stiff breeze. Dr. Ash had no means of measuring the quantity of rain that fell, but the floods of water which came down the surrounding hills was unusually great, causing the flats to have the appearance of pools.

As observed by Enos Sharpless, at Waterville, a short distance north of Chester, it rained more or less the greater part of the day, moderately until about six o'clock, when there was a pretty heavy shower. He thinks there was little wind at any time.

As observed by Caleb Pierce, of Chester, the commencement of the heavy rain was about quarter past five o'clock, P. M., and its continuance about half an hour. In the afternoon thunder was heard, which continued some time, though at a distance. At about three o'clock it became so dark as to render it difficult to read in the house without a light. In a north-west direction from this place, there was an appearance of the clouds or gusts meeting, and the rain pouring down at a distance, which appearance lasted for some time. At the commencement of the heavy rain, the wind was S. E., but during the heavy shower it came from the north-west. After the heavy shower, it boxed round the compass in the space of five minutes.

As observed by Jonathan Dutton, at his mills in the northern part of Chester township, the heavy rain commenced about five o'clock, and terminated about half past six, P. M. The direction of the wind was N. E. till about five o'clock, when it changed to West, and blew a smart gale, but not

what he would consider a violent one. The quantity of rain which fell was not ascertained.

As observed by James Riddle, at Avendale, about two and a half miles N. E. from Chester, the wind blew from the southward and eastward all day till the evening, when it blew a gale from the north-west, Very little rain fell during the whole day till evening, when there was a smart shower, but nothing of any amount to make a rise in the creek. A gentleman residing in Concord township, informed Mr. Riddle that the wind changed at least five times, according to his own observations, in that township.

As observed by Robert Frame, Esq., at his residence in the township of Birmingham, the rain commenced about noon, the wind in the east or south-east. The clouds were dark and heavy, the lightning sharp, and the thunder tremendously heavy, accompanied with a rumbling noise in the air. The wind blew hard and was whiffing, and the rain fell in torrents till two, or perhaps half past two o'clock, when it subsided for ten or fifteen minutes, after which—the wind in the west, or south-west,—the clouds appeared to discharge their contents with redoubled fury. The rain ceased about four o'clock, P. M.

Mr. Joseph Edwards, who resides in Middletown township, within half a mile of the centre of the county, observed a phenomenon during the last heavy shower of rain, which does not appear to have been noticed in any other part of the county. He remarks that during the last shower which continued, say twenty minutes, and in which there fell a greater quantity of water than during any equal space of time during the afternoon—unlike any other shower he had witnessed—the distant woods and other objects were not obscured in any sensible degree by the falling rain. This extraordinary appearance was a subject of remark by all present, and created considerable surprise. At the time there was an impending mass of dense clouds, without any apparent

motion in the air. This particular shower approached from the south, unaccompanied by wind.

The foregoing embraces all the observations made on the storm in Delaware county, which have been communicated to the committee. On the evening of the same day, a very violent gale passed over the extreme western part of the city of Philadelphia, in a northern, or north-western direction. In its course, it unroofed a part of the gas works; prostrated trees; overturned the railing on the eastern abutment of the Permanent bridge; carried many boards, &c., from a lumber yard in that vicinity, to a considerable distance, besides causing other damage. This gale appears to have been accompanied with considerable rain which extended higher up the Schuylkill river. This does not appear to have been the case in a southward direction from the city, as at Fort Mifflin in the Delaware, a little below the mouth of the Schuylkill, but two and three quarter inches of rain fell, as accurately measured by a rain gauge kept at that place.

The hurricane which has been described as occurring in Bethel township, appears to have extended into Brandywine Hundred, in the State of Delaware. It proceeded here in a narrow vein, not more than one-eighth of a mile in width, prostrating forest and fruit trees and fences in every direction, and causing considerable damage to buildings. The barn of Uriel Pierce was blown down, and the roof of George Miller's dwelling was blown off, and carried to a considerable distance; a bed, bed clothes and wearing apparel were carried by the wind from Mr. Miller's house, a distance of nearly a mile.

THE FLOOD.

The most remarkable circumstance connected with the rise in the waters of the several streams, was its extreme suddenness. In this particular, the present flood probably has but

few parallels on record; occurring in a temperate climate, and being the result of rain alone. The description given by many persons of its approach in the lower districts of the county, forcibly reminds one of the accounts he has read of the advance of the tides in the bay of Fundy, and other places where they attain a great height. Some speak of the water as coming down in a breast of several feet at a time; others describe it as approaching in waves which followed each other in rapid succession; but all agree that at one period of the flood, there was an almost instantaneous rise in the water of from five to eight or ten feet. The time at which this extreme rapidity in the rise of the water occurred, was (in most cases) after the streams had become so much swollen as to nearly or quite fill their ordinary channels. The quantity of water required to produce such a phenomenon, was therefore immensely greater, as the valleys of the streams in most places have a transverse section of several hundred feet. The breaking of mill dams, and the yielding of bridges and other obstructions, no doubt contributed in a degree to produce such an extraordinary swell, but we must mainly look for the cause of this sudden rush of waters, to the violence of the rain, if the term *rain* will apply to the torrents of water which fell in the northern and western sections of the county.

The rapidity in the fall of the water after the flood had obtained its maximum height, corresponded in a measure with its rise. Chester creek at Flower's mill, was observed to fall ten feet in fifty minutes, or at the rate of one foot in five minutes. Though not so accurately observed, it is probable the other streams fell at a corresponding rate. At the earliest dawn on the following morning, the streams had retired within their ordinary beds, scarcely presenting miniature pictures of the mighty torrents which had swept through their valleys on the preceding evening.

Commencing on the eastern border of the county, the effects of the flood in the several large streams will be partic-

ularly noticed, in the order that they occur in proceeding westward.

Cobb's Creek.—It has been before observed that the flood in this stream did not rise to an unusual height. It is only adverted to at all as a matter of contrast, and for the purpose of defining the eastern border of the district of country upon which the greatest force of the rain storm was expended. At Seller's mill, on the West Chester road, this stream only attained the height of six feet and half, and at the head of tide water it did not reach the height of previous floods, by two feet. Nailor's run, its principal tributary, was raised about in an equal degree. Near the sources of both these streams, in the township of Haverford, the rain fell with considerable violence for some time. At Haverford School, which is within the drainage of Cobb's creek, 5.82 inches of rain fell, as accurately measured by a rain guage kept at that institution.

The contrast between the flood in Cobbs and Darby creeks was very striking at the head of tide water, where they approach each other within less than a mile. At the time the latter had risen to a height of about seventeen feet and swept every thing before it, the former presented nothing beyond an ordinary freshet.

Darby Creek.—Proceeding westward, this is the first large stream which properly comes within the scope of the present inquiry. Ithen creek, one of its principal branches, attained a height never before witnessed by the oldest inhabitants, and was the cause of considerable destruction of property. The bridge over this stream where it is crossed by the old Lancaster road, near Radnor Friends' Meeting house, was carried away. This was a stone bridge with a single arch of twenty-five feet span, and its location within about two miles of the head waters of the creek. Even here the volume of water was so great that in forcing itself through the aperture presented by the arch, the abutments were undermined to such an extent as to cause the bridge to fall. The mill dam of

Jesse Brooke, a short distance below, was partly carried away, and that of John Evans, still lower down the stream, entirely swept out. Mr. E. also had a large quantity of lumber carried away, and sustained other losses.

With the exception of fences, crops, &c., no serious damage was sustained on what is called the eastern branch of Darby creek, above its union with the west branch. Its waters were raised, however, to an unprecedented height. Some damage resulted from the flood on the west branch of this stream, before it enters Delaware county. Thomas' mill dam, a short distance above the county line, it is understood, was entirely swept away. At the bridge near Mr. William Crossley's factory, the water attained a height of ten feet, and but for the flat around the north-east abutment, the bridge must have yielded to the force of the flood. As it was, the bridge, although wholly constructed of stone, was observed to oscillate so perceptibly as to alarm a number of by-standers for its safety. Mr. Crossley sustained some loss from having the basement of his factory flooded. Samuel Moore & Co., who own and occupy two woollen factories, next below Mr. Crossley's had both their dams destroyed. The small dam on this stream, which turns its waters into the main dam belonging to Levi Lewis' mill, is also said to have been broken, as well as the side bank of the main dam itself. The saw-mill dam of Mr. Lewis, which is on a tributary that empties into Darby creek, a short distance below his flour mill, was also broken. From Mr. Lewis' mills to a point near Hood's bridge, the creek has ample room to spread, and was productive of little damage, except to fences, &c. Near this point the water rose to the height of fourteen feet, being seven feet higher than the ice freshet of January 26th, 1839. Hood's bridge, which was a stone structure of two twenty feet arches, erected in 1836, at a cost of \$1,553 to the county, had both arches swept out, and the abutments nearly destroyed. It may be regarded as a total loss.

After leaving this bridge, the creek has wide flats to the

point where it is joined by Ithen creek, and for a short distance below. Near Wright's saw-mill, where the creek had room to spread several hundred feet, the flood only attained a height of nine feet four inches. The mill dam and race of Clement & William P. Lawrence was considerably injured—the saw-mill damaged to some extent, and lumber belonging to several persons was carried away. These mills are located at the point where the creek is crossed by the West Chester road. More than one hundred feet of the western wing walls and filling of the stone bridge at this place were swept away to the foundations, and the abutments considerably undermined. At this point on the creek, both above and below the bridge, the flood attained a height of thirteen feet nine inches, and was at its greatest height at a quarter before 8 o'clock. At Joseph B. Leedom's flour and saw-mill, but little damage was sustained, they being located on a curve of the valley of the creek, which saved them from the force of the current. At this point the water rose to a height of thirteen feet two inches. The stone bridge, a short distance below Leedom's mills, had a large proportion of its guard walls swept off. The flood attained a height of fifteen feet at this place, with a cross section of eighty yards, which with proper allowances, would give an area of two thousand eight hundred square feet. The next bridge below, near William W. Clement's, which is built on the lattice plan, in consequence of being located on a western curve of the creek, with a flat of more than seven hundred and fifty feet at its eastern end, sustained no injury. In fact the bridge was not subjected to the least danger from drifting timber, &c., as the current of the flood ceased to pass near the ordinary channel of the creek, long before it attained its maximum height. About a fourth of a mile below this bridge, near the foot of E. Levis' meadow, the flood reached the height of fourteen feet six inches. A few hundred yards below this point, in the timber land of N. Garrett, deceased, it attained a height of seventeen feet, being six feet six inches higher than the

ice freshet of 1839. This sudden change in the height of the water in so short a distance, must have been altogether owing to the obstruction caused by the thick growth of young timber, as at Palmer & Marker's mill, half a mile below, the water only attained a height of fourteen feet—the width of the valley of the creek being about alike in both places. But slight damage was sustained at the woollen factory owned by Oborn Levis, and occupied by Moses Hey. The lower story was flooded, and the machinery somewhat injured. Next below is Palmer & Marker's paper mill, which exhibits the destructive power of the flood in a very striking manner. Thirty feet of this mill was washed down, and the balance much shattered, a paper machine ruined, and their race and dam considerably injured. Upon the site of a very productive garden, there is nothing now to be seen but rocks denuded of every particle of earth, while a few yards below, a deposite of stone, &c., covers three-fourths of an acre. Mr. Oborn Levis' dam was swept out entirely—his race broken in some places, and filled with stones and gravel in others. The sizing-house attached to his paper mill, was swept away to the foundation, and the basement story of the main building with its contents, was greatly damaged by the flood bursting through the door and windows on one side of the building, and passing out at the same avenues on the other side. Opposite to this mill, on the eastern side of the creek, were a number of gardens belonging to the workmen. Scarcely a vestige of vegetation is now left to mark their site, and over a considerable portion of it, nothing is to be seen, but a bed of rocks. The next improvements below, are on the estate of Thomas Garrett, deceased, and it was here where the flood, in this creek, proved the most destructive to private property. A small cotton factory on these premises, occupied by John and Thomas Kent, with its entire contents of machinery, stock in trade, &c., was swept away ; an unoccupied dwelling was so completely carried away, that no part of it remains to mark the site upon which it stood. The large dam on this

property was swept away, and also a considerable portion of the race, and several private bridges. Three stone dwellings were partly carried away, and rendered complete wrecks. At the large factory occupied by Dennis & Charles Kelly, the stone picker house, with its contents, was swept off, and the basement story of the main building flooded. The flood attained a height of sixteen and a half feet on these premises, and was at its greatest height at about a quarter past eight o'clock.

D. & C. Kelly also occupy the next mill property, which is a large cotton factory belonging to the estate of Asher Lobb, deceased. Their dam was carried away, the race injured, and the lower story of the factory (used as a weaving room) flooded, and one dwelling house carried away, causing the loss of five lives. The particulars of this catastrophe will be detailed in another part of this report. The western wing-walls of the bridge at this place with the filling, were nearly all swept away, and two of the three arches greatly injured. The height of the flood at this place was fourteen feet, and the time of its greatest height, half past eight o'clock. The dam of Matthew's paper mill was washed out to the foundation, and a part of the race bank carried away. The flood passed with violence through every aperture in the lower story of the mill, doing great damage to the machinery and stock on hand. The water rose to the height of fifteen feet at this mill. Bonsall's mill dam and race were considerably injured. The water was sixteen feet high in their flour mill.

Thomas Steel's dam, which is the last on the creek, was carried away to the foundation, and his stable and cotton house were removed. His mill was much flooded, the water rising to the height of seventeen and a half feet, which is the greatest height reached by the flood in Darby creek, and five and a half feet higher than any flood recollected. The stone bridge at Darby, which reached across the entire valley of the creek, and which was built at a cost to the county of eleven

thousand dollars, had its three arches entirely swept out. These arches would probably have been insufficient to pass one half of the water of this flood. Thomas Glascoe's dwelling and furniture were greatly injured, as was also the furniture of other persons in houses belonging to him. The artificial banks of the creek below were broken in several places, and a quantity of hay carried off.

Above Garrett's but few trees were uprooted by the flood, but below that place, a number of considerable size yielded to the force of the current. None of the tributaries of this creek, which empty within four miles of tide, were flooded in a very extraordinary manner. Those above were raised higher than ever before witnessed, and several of them were productive of considerable damage in the destruction of culverts, fences, &c., and by the deposition of large stones, gravel and sand upon meadows.

It will be perceived that Darby creek has a less descent than either Crum, Ridley, or Chester. It may also be observed, that the hills which border it are not quite so high, and in general it has a wider valley than either of those streams, though in some places it is closely approached by the hills, particularly in the district where the greatest amount of damage was sustained.

Crum creek.—Proceeding westward, this is the next of the large inundated creeks. The flood in this stream attained a greater height than in Darby creek—was productive of much damage to bridges and private property, but was unaccompanied with any loss of human life.

Except to fences, &c., the flood in Crum creek evinced but little of its destructive force, before entering the borders of Delaware county. Immediately below the Chester county line, at the factory of Jonathan N. Hatch, an unoccupied frame tenement was carried away. The extensive stone bridge at the West Chester, or Strasburg road, which was built at an expense to the county of ten thousand dollars, and which had a water way of thirty-two feet, had its arch com-

pletely swept out, one of its abutments undermined, and thirty feet of each end of the wing-walls carried away. Immediately below the point where the road from Newtown Square crosses the creek, the flood reached the height of nine feet upon a cross section at the surface of three hundred and thirty feet. The saw mill of Adam B. and Enos Williamson, and S. Bishop, with the appurtenances was damaged to some extent. The stone arched bridge, near this place, known as "Howard's bridge," was almost wholly destroyed. It may be regarded as a total loss. The next bridge below, near Bartram's, a sleeper bridge, was entirely swept away. The next point at which the flood exhibited any degree of violence, was at T. Chalkley Palmer's mills. Mr. Palmer's flour mill stands immediately at the breast of the dam. Between the mill and the high ground on the west side of the creek, there was a very wide and strong embankment. This embankment was carried away, and an extensive excavation made below to the depth of twelve feet. Immediately facing this embankment stood a large stone wagon house which was fifty feet in length—this building was entirely carried away, with a considerable part of its contents, including a quantity of hay. The wood work of the sleeper bridge at this place was carried off, and the abutments injured. The water near Mr. Palmer's mill rose to the height of twelve feet. The branch of Crum creek which joins it some distance below this point, and upon which Willet Paxson's saw-mill is located, was very high and turbulent, and caused considerable damage. Mr. Paxson's saw-mill dam was swept out. At Holland's bridge on the road from Springfield Meeting House to the Rose Tree, the water attained a height of thirteen feet three inches. Though the water has ample room to spread at this point, it made a deep channel through the western abutment of the bridge, and rendered it very much of a wreck. The damage to Felix Velott, near this place, in crops and fences was very severe. We next come to the mills of John C. Beatty, one of the points upon this creek

where very heavy damage was sustained. The dam attached to these mills was considered one of the best in the county. The water was used for the various purposes necessary for carrying on an extensive edge tool manufactory; for propelling a flour mill, saw mill and plaster mill, all of which, except the flour mill, were carried away, together with the county bridge, which stood immediately below. The circumstances connected with the rise in the water, and the destruction of his property, is thus described by Mr. Beatty: "At about five o'clock, P. M., the creek began to rise, when several of the workmen, with myself, went to the shop to secure some timber which was afloat and likely to be washed away; but we had not time to make any thing safe, before we were obliged to make our escape, which, if we had not done at the time we did, we must have been washed with the mills down the creek. The water in the space of ten minutes, rose, I think, seven or eight feet. The bridge was the first that went—it seemed to fall over as if there was no strength in it—then my wood-house, with about ten cords of wood and a lot of chestnut rails—next the head gates were bursted out, when the edge tool factory went down with a tremendous crash, and in an instant there was nothing to be seen but water in the place where it stood. The saw-mill was the next to yield to the violence of the flood, and all the logs, plank, boards, &c., near it were carried away. The walls of the plaster mill and finishing mill were undermined, and those in front fell out, leaving the back and end walls in such a wrecked condition, that they fell in a few days after. About half the race bank, and eight yards of the breast of the dam, were completely swept out. All the hammers, anvils, unfinished tools, coal, &c., were swept away, or covered with stones and dirt below." The water at this place rose to a height of about fourteen feet above its usual level.

The paper mill of John Lewis is a short distance below Mr. Beatty's. Part of his dam was broken down, the head gates forced in, and considerable injury done to his machinery

by being flooded. Opposite Joel Evan's farm, a short distance below the paper mill, the water rose twelve feet above its usual level.

The bridge at the turnpike over the dam of George Lewis, was a roofed lattice bridge, with a span of ninety feet. It was nearly new and had been erected at an expense to the county of four thousand six hundred dollars. The wood work of this bridge was completely carried off. The mill dam of George Lewis was carried away, as was also his dye-house, a stone building of considerable size. His race was partly filled up, and the machinery in the mill considerably injured by being flooded. The water rose twenty feet above its usual level—seven feet higher than ever before noticed.

The next establishments on the creek below, are the Strathaven and Avendale cotton factories, owned by William J. Leiper, and both occupied by James Riddle. Both dams were partially swept away, and a number of the tenant houses injured. All the tenant houses at Avendale were under water to the second story, but being constructed of stone, were not demolished. Mr. Riddle had a large quantity of cotton in bales, carried away, and a considerable amount of cotton goods, yarns, &c., damaged. Mr. Riddle observes, "that the water at this place rose nineteen feet—six feet higher than the great ice freshet of 1839. The rise in the creek commenced at about half past seven o'clock. The water rose very suddenly as well as very unexpectedly, and was at its highest point a little after eight o'clock." The county bridge at this place had its guard walls completely swept off and was otherwise greatly damaged, but the arches remained firm. A team of five horses, owned by Samuel Beard, was in the stable at Avendale, but so rapid was the rise in the water, that they were all drowned before they could be got out.

Below this point the Hon. George G. Leiper sustained considerable loss in damage to his mill dams, breaches in his canal, and injury to private roads through his property—he

also lost a horse from drowning. The sleeper bridge, near Mr. Leiper's, was carried away. Mr. L's. factories were not materially injured, and their occupants sustained but little loss from the flood. The location of the stone bridge at the post-road, being out of the current of the flood, sustained but little injury. A small portion of the western wing walls was carried away.

The height of the flood in this creek, it will be seen, did not exceed that in Darby creek at corresponding points, until you reach Beatty's mills. Below that place it was an average about two feet higher. This is readily accounted for by the fact, that the very heavy rain was more protracted, and extended lower down the valley of Crum than of Darby creek.

Ridley creek.—The flood in this creek caused some damage above the boundary line which separates this county from Chester, but nothing very material. Yarnall's mill dam, which is on a tributary, and within the borders of this county, was injured to some extent. The county bridge, known as "Russell's," on the main stream, sustained some damage. The first place on this creek, from which the committee have any very particular account of the flood, is on the farm of George Howard, in Edgmont. At this place the water attained a height of twelve feet six inches, which was six feet six inches higher than the great freshet of 1839, and six feet four inches higher than that of 1795; this last being the highest which had previously occurred at the same place, during a period of at least ninety years. Although the rise in the water of the present flood was about twice as great as that of 1795, the quantity of water which passed at a given time was greatly more than double. A cross section of the flood of '95 gives but nine hundred square feet, while that of 1843, gives upwards of two thousand five hundred square feet. By making a proper allowance for the accelerated velocity of the flood of 1843 over that of 1795, which would be necessarily incident to its increase of volume, it is rendered probable that more than three times as much water passed in a

given time during the present freshet, as in that of 1795. The time of the greatest height of the water was half past six o'clock. The above information was furnished by James Howard.

The first heavy loss of property on this stream, occurred at Amor Bishop's mills. His dam was entirely carried away, together with a part of the race—his mills, also, were considerably damaged. Two tenements which stood near the creek, with the furniture which they contained, were carried away, but no lives were endangered. The flood at this place reached its greatest height about six o'clock, and was ten and a half feet above usual low water. The abutments of the bridge at Bishop's were swept away, with the exception of barely enough of the face wall to support the wood work, which, singularly enough, remains in its original position, except the hand-railing, which shared the fate of the abutments. This was a sleeper bridge of one span—the abutments being founded on the solid rock. The abutment on the western side of the creek is so nearly carried away as to allow a portion of the stream at low water to flow where it stood—its facing stones alone being left to support the ends of the sleepers. These, with the planking, remained so firmly that they do not appear to have moved the fraction of an inch. While every thing was yielding around it, so firmly was this bridge held to its place, that during the height of the flood, large floating trees were observed to strike against it with great force—their roots being drawn under it, and their tops thrown many feet out of the water.

A member of the committee has made a careful examination of the subject, with a view of ascertaining the principles upon which the floor of this bridge was enabled to maintain its position, perched up on the tottering ruins of the abutments. The following is the result of that examination :

The water, at its height near the margin of the stream, and forty-three yards above the bridge, was ten feet six inches. Its greatest height on the margin of the flood, oppo-

site to the bridge, was two feet nine inches above the level of the floor of the bridge, while the water on the floor of the bridge was at least three feet six inches high. This shows that the water at the bridge, near the middle of the flood, was nine inches higher than at the margin. Forty yards below the bridge, on the margin of the stream, the water stood one foot lower than the level of the floor of the bridge. At forty-three yards above the bridge, on the margin of the flood, the water was three feet higher than the level of the floor of the bridge. The floor of the bridge is seven feet three inches above low water. The fall in the creek for one hundred and eighty yards above the bridge is .16 of an inch to the yard, and for two hundred and forty yards below the bridge, the fall is .12 of an inch to the yard. The width of the valley of the creek occupied by the flood at the bridge, is sixty-four yards. The width of the valley below the bridge, at the narrowest place at high water mark, is eighty-six yards, from which point the valley continues to widen for some distance below.

From these measurements it would appear that the bridge occupied a position, below which the valley of the creek suddenly expanded, and consequently the same volume of water in passing down could not remain at the same elevation below as it did above the bridge, by nearly four feet, according to the foregoing data.

It has been before stated, that forty-three yards below the bridge, the high water mark on shore was one foot below the level of the bridge, and it was also stated, that the middle of the current, at the bridge, was nine inches higher than at the margin; but it is probable that in consequence of the valley becoming wider, the middle of the current, forty-three yards below, would not stand so many inches above the height at the margin. There must, therefore, have been a great deficiency of water below the bridge to counterbalance that which was above and that which rested upon it. The length of the platform of the bridge is thirty-six feet, its breadth fourteen

and a half feet, and the depth of water upon it three feet six inches, making 1827 cubic feet of water on the bridge, which is equal to about fifty tons. It is not to be supposed that the whole of this great weight was supported by the bridge, but it is manifest that a great portion of it was, and this will be a sufficient explanation of the extraordinary fact, that the timbers did not float off, and why they firmly held that portion of the abutments upon which they rested, in defiance of the drifting trees and lumber, which by their momentum acted against it like battering rams. Had not the bridge been fastened together, it no doubt would have been removed piece by piece.

The bridge was originally built by private subscription, and was so maintained for a long time before it became a county bridge; it was one foot lower then than at present. During the whole time the sleepers merely rested on the walls without being secured with bolts or other fastening.

The extraordinary preservation of the platform of the bridge certainly goes to show, that bridges in certain situations may with safety be erected so low as to permit high freshets to pass over them. Very large sized stones should be used in the masonry, particularly for coping, and in the construction of the exposed corners, and the timbers should be firmly secured to the abutments. The walls should in no place exceed the height of the roadway; and it would add to the security of the bridge to have the up-stream side of the platform lower than the down-stream side.

All the woodwork of the bridge, near Edward Lewis' mills was carried away, and the abutments considerably injured. The valley of the creek at this place is very narrow. Mr. Lewis' paper mill stood in an exposed situation, and was, together with its contents, wholly swept off. The saw mill shared the same fate, although it was not so much exposed to the current. His flour mill was nearly destroyed, and much of its contents washed out. Between his mills and dwelling the flood passed with fearful velocity, and produced an excav-

ation of great depth. The water at this place rose to the height of eighteen feet, and was at its greatest height about 6 o'clock.

The next mill below is a woollen factory, owned by Charles Sherman, and occupied by E. Taylor. Their dam was partly destroyed, the head washed out, and the race considerably injured. Three dwellings were carried away, the mill itself much injured, and the machinery and goods in the lower story were either destroyed or greatly damaged. Greatest height of the water fourteen feet.

The next mill in order is the woollen factory of Samuel Bancroft (formerly Ronalson's.) The flood attained a height of twenty feet, and was very destructive at this point. Fifty by thirty-six feet of the factory was *entirely* destroyed, with a large amount of machinery, and one thousand pounds of wool. Four dwellings were also nearly demolished, occasioning the loss of five lives. The water was at its greatest height at half past six o'clock.

On a tributary of Ridley creek, in this neighborhood, the flour mill dam of Thomas Hutton was entirely swept away.

At the paper mill of Park Shee, Esq., the breast of his dam and the mill itself were much injured. Two small buildings were destroyed. The water rose to the height of twenty feet.

At Charles Sherman's lower factory (formerly Benninghoves,) occupied by E. Taylor, the dam was swept away, and the machine manufactory and picker house (one large building,) with all their valuable machinery, were washed down and destroyed. A quantity of wool and cotton were carried off, and the machinery and goods in the basement story of the mill were greatly damaged. The water rose fourteen feet, and was at its greatest height about 7 o'clock.

The bridge between this mill and the rolling mill of J. G. Johnson was nearly destroyed, the wood work entirely carried off, and the abutments greatly damaged. The damage sustained by Mr. Johnson at his mills was, comparatively, not

very serious. His buildings were injured, and a considerable quantity of iron damaged.

At the mills of Enos Sharpless the water rose to the height of eighteen feet, being at its greatest height a little after eight o'clock. At this place the present flood was seven feet three inches higher than the great ice freshet of 1839, and eight feet three inches higher than the flood of 1795. The king post bridge, near these mills, was carried away, but as it was lodged within a mile, the materials were chiefly recovered, and the bridge rebuilt without great expense to the county. The counting house, a temporary bark house, and bath house were carried away. The basements of the mills were flooded, and the cards in the woolen mill, and the bolting cloths in the flour mill were damaged. The injury to Mr. Sharpless' dam was very considerable—about half of the breast-work, and nearly all of the filling above (constituting about three-fourths of the entire dam,) were carried away. The fixtures for raising the logs into Crosby's dam were demolished, and a number of logs carried off. John M. Sharpless, at these same mills, had a Cooper shop, with casks, lumber, &c., carried away. The next bridge below was over Crosby's dam. It was of great length, reaching from hill to hill, constructed entirely of stone, and had been built at a heavy expense to the county. The arches of this bridge were completely swept out, and one abutment nearly destroyed. The loss to the county will necessarily be very heavy.

At Peirce Crosby's mills the water, during the flood, was twenty-one feet high, which is the greatest height noticed on this creek, and seven feet higher than any previous flood recollected by any person living. A large portion of Mr. Crosby's dam was carried away, his race filled up, one tenement carried off, and his flour mill and saw mill partially injured. Edward R. Crosby had a quantity of logs and boards carried away. The bridge at this place was also carried off, but the loss to the county was not very great. Mr. Peirce Crosby observed, during the greatest height of the

water, a very marked difference between the height of the margin of the flood and the middle of the current. He is of opinion that the difference in height did not fall much short of three feet.

The eastern abutment of the king post bridge at the southern road, together with the superstructure was carried away. The rail-road bridge over this creek was greatly damaged—the extensive trussel work on the eastern shore being swept off.

The flood appears to have attained rather a greater elevation in this creek than in Crum. The destruction which was caused by it (without including the loss of life,) was infinitely greater. The number of trees which was uprooted and carried down was very considerable, and many of them of a large size.

Chester creek.—We have now arrived at the most westward of the *large* inundated creeks. In this stream the flood attained its maximum height, and greatly exceeded that in either of the foregoing streams in force and velocity, and in the destruction of property. The same number of lives were lost upon this creek as upon Darby creek.

In the brief topographical view which was given of the county, it is mentioned that Chester creek has its origin by two principal branches termed “East” and “West,” but so violent was the fall of rain in this region of the county, that our observations in tracing the flood will have to be extended to some of the subdivisions of these branches.

On the principal division of the east branch, no serious damage occurred, except to fences, crops, &c., above the rolling mill and nail factory of John Edwards, Esq., deceased, both of which were unoccupied. On this property the dam was swept out and the race broken.

The next establishment on this stream below, is the flour and paper mills of James M. Wilcox, Esq. His dam was injured and an extensive protection wall at the end of his mill washed down. The injury done to Abraham Sharpless’ saw mill, if any, has not been ascertained.

The tilt mill belonging to the heirs of Thomas Thatcher, deceased, was wholly carried away—nothing being left but the tilt hammer and the grindstone. Grubb's bridge, on the State road, was considerably injured. This bridge was built in 1840, at a cost to the county of one thousand six hundred and sixty-six dollars. The damage will amount to about one-fifth of the original cost.

The next mill property on this stream is a cotton factory belonging to the trustee of Hannah S. Hill, and occupied by Daniel Lamott & Son. The water was at its highest point about six o'clock, and had risen eighteen feet above its ordinary level. The Messrs. Lamott sustained a heavy loss in goods, yarns, &c. The county bridge at this place was so nearly destroyed that it may be set down as a total loss. The damage to the real estate was also very considerable, the dam and the race being swept away. The next mill below, near the junction of the two main branches of the creek, is a large cotton factory belonging to the same estate. It was unoccupied at the time. Here the damage was also very considerable. The dam was injured, the forebay swept out, and the water-wheel was thrown out of its position.

On Rocky run, or Martin's run, a tributary of this main East branch of Chester creek, David Green's cotton factory was considerably injured. The mill was stone, one story—the balance frame. A large part of this stone work was undermined, and has given way; but enough has remained firm to support the frame-work above. Mr. Green's dam was swept out, although located within a mile of the source of the stream.

On this stream, the next mill below, is the flour mill of Humphrey Yearsley. His dam was broken, and his property otherwise injured.

The saw mill dam of Joseph Pennel, the last on this tributary, was also broken. Ninety feet of an earthen embankment was carried away.

Commencing on what may be termed the main West

branch of Chester creek, the first mill property in Delaware county, belongs to Caleb Brinton. It is occupied as a grist mill, saw mill and clover mill. His dam was broken, and his race considerably injured. The next mill below, is the flour mill of Matthew Ash. His dam was also broken, and his race partly filled up. His loss, however, was not very heavy.

Casper W. Sharpless, Esq., had his saw mill dam entirely swept out, and his flour mill dams broken. The water, near the flour mill of Mr. Sharpless, rose to the height of ten feet above the usual level. At Jesse Myers' saw mill, which is upon a south westerly branch of this stream, the water was seven feet eight inches upon a cross section of sixty yards. being three feet eight inches higher than ever before known.

Next below the flour mill of Mr. Sharpless, is the cotton factory of Joseph M. Trimble. His dam was broken and his race partly filled.

The paper mill of James M. Wilcox, Esq., is the next below. A quantity of paper was lost from this mill; his dam was broken, and his race injured. A building which contained a large quantity of paper was removed several feet, but was not carried away. Proceeding down the main stream, we must arrive at the mills of James S. Tyson. At this place the flood exhibited its transporting and destructive powers in no slight degree. Mr. Tyson's dam and race were swept out, and a dwelling house occupied by a Mr. Kenworthy was entirely carried away, together with much of his household goods. The family, on the approach of danger, had removed to a place of safety. The county bridge at this place was completely carried away. The altered appearance of the valley of the creek in this vicinity is very great.

About one mile below Mr. Tyson's mills is John P. Crozer's "West Branch" cotton factory, which is within about three-eighths of a mile of the junction of the East and West branches of the creek, near which point, at Crozerville, Mr. C. has another Cotton factory, also propelled by the waters of the West branch. Upon these premises the power of the

flood was expended with the most terrific violence. In an hour after the commencement of the heavy rain, both the East and West forks were observed to rise rapidly—the east fork at first rose more rapidly of the two, but subsequently the West branch swelled greatly the higher: the comparative volume of these two streams in their natural flow, is about as three to two—the East branch being the larger. Shortly after four o'clock, Mr. Crozer sent his son to the West Branch mill to order some precautionary measures, as he foresaw the approach of an unusual freshet. So rapid was the rise in the water, that soon after young Mr. Crozer had crossed the bridge, its wood-work floated off. When he reached the West branch mill, he found the workmen already engaged in removing goods from the lower to the upper story of the warehouse—to what little purpose will soon appear.

At a quarter before five o'clock, the West branch dam (a pond of nearly ten acres surface) gave way, and at five o'clock the warehouse, a large stone building, containing many thousand dollars worth of goods and yarns, began to yield to the current. That side of the wall next to the central current began to knock out, stone by stone, and in a few minutes, the roof and the entire building went with a fearful crash, sending up a volume of dust from the mortared wall, so as to induce those present to suppose the building was on fire. About the same time, or soon afterward, the water wheel, mill gearing, dye house and size house, with their contents floated down, and were soon crushed to pieces: the water wheel shaft was afterwards found two miles below, but nothing else of value was recovered. Next in order the northern wing of the West branch factory, a three story building forty-eight by thirty feet, began to fall, and with its valuable contents of over eighty power looms and much other machinery, with goods, yarns, &c., soon disappeared. The sweeping ruin was not yet over: the centre building had one entire corner carried out to its foundation, which caused the floors to hang over, under their ponderous weight of machinery.

The work of destruction was now nearly completed, and the people looked on with momentary expectation of seeing the whole factory fall, but in this critical and wrecked condition it remained. The machinery was much injured—some of it swept off, but the building has since been repaired, and is now in operation. When the waters had subsided, the place exhibited an altered appearance. A grove near the dwelling of Mr. Crozer, but on the opposite side of the stream, was entirely stripped of its trees, and as a substitute for the green sward upon which they grew, the whole surface remains covered with rocks, stone and gravel; while on the opposite side of the stream, and below the house and Crozerville factory, the green flat is enveloped in a deposit of mud several inches in depth. This latter deposit is made just above the junction of the two branches. The waters of the West branch flowing down in mad haste, backed up the valley of the East branch. It appeared to form a water bulwark, which caused the latter stream to move at this place, with much less impetuosity, and hence the deposit of mud. The rise of the waters of the West branch fork was twenty-three feet, and fully ten feet higher than the great ice freshet of 1839. The time of its greatest height at West branch mill, was about half past five o'clock. Soon after this time the flood began to subside, and fell rapidly. The bridge at Crozerville was entirely carried off—the abutments being razed to their foundation.

Crozerville spinning mill was flooded and the machinery in the lower story a good deal injured—the cotton house, with about thirty bales of cotton, together with property of less value, was swept away. Opposite to this factory the channel of the creek was completely filled with rocks, stones, and gravel, and the stream, after the flood had subsided was obliged to find its way downwards through the tail race of the mill.

Upon Green's creek, a stream putting into the main West branch from the south, and emptying into it above Mr. Tyson's mills, the flood attained an extraordinary height, and

exhibited great force in uprooting and transporting trees, excavating the soil, &c. It is probable that fully as much rain fell in the valley of this stream, as in any other section of the county of equal extent. The dam and part of the race of Samuel F. Peters' near the mouth of this creek, were swept out, and his property otherwise injured. The water was eight inches on the roof of his saw-mill, and attained a height of 20.5 feet, being eight feet three inches higher than the ice freshet of 1839.

Below the junction of the two main branches of the creek, the flood swept along with increased force and violence. Trees of a large size were uprooted, and carried down; rocks of great weight were removed from the places where they had quietly reposed for ages; beautiful green meadows and gardens were divested of every particle of soil, or covered with heavy deposits of rocks, stones, gravel, and sand, while the wrecks of buildings floating from above aided in the destruction of those upon the united stream.

The dam and race bank of Samuel Riddle's cotton factory (the first on the united stream) were carried away, together with an old mill; and his machinery was considerably injured. Mr. Riddle's establishment is at Pennsgrove. At this place the flood reached the height of twenty-three feet ten inches above the usual level of the stream, and was at its greatest height about six o'clock. George Peterson, the owner of two double stone houses, situated on the margin of the stream, near Pennsgrove, was a heavy sufferer in proportion to the value of his property. One of the double houses was swept away, and the other occupied by himself, much wrecked, and the furniture washed out, and mostly carried off. In the same vicinity, four small tenements owned by John Rhodes, and occupied by himself, Joseph Drake, Thomas McGuigan, Mrs. Morton, and Mrs. McClese, were, with all the household goods which they contained, swept off, leaving no trace of a building upon the site where they stood, and causing the loss of six lives, the particulars concerning which will be given in

another place. A stone house, the property of E. Churchman, standing near the four above mentioned, was very much damaged. The county bridge at Pennsgrove, except the piers, was carried away. Shortly before the flood, the county had expended about four hundred dollars in repairs upon this bridge.

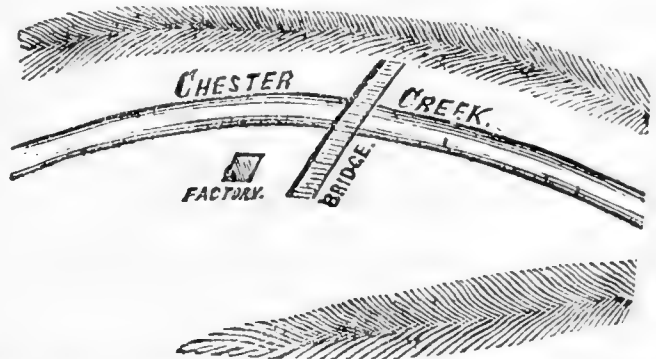
Below this, at Rockdale, Richard S. Smith had two dams carried away, and also a block of four stone dwellings, which at the time were unoccupied.

At Knowlton, the flood attained its greatest height, and exhibited its most destructive powers. The Knowlton mill, a beautiful three story stone factory, 76 feet by 36, and filled with power looms, all new, and of the best construction, together with all the apparatus and arrangements of a complete weaving establishment, was swept to its foundation, and carried away, and with it a large amount of stock in yarns and goods. A frame mill at the same place, also owned by Mr. Crozer, and occupied by James Dixon (the machinery being owned by him) was carried down the stream: not a vestige of it remaining. The loss to James Dixon was total and ruinous, stripping him of all he possessed.

The water at Knowlton attained a height of about thirty-three feet. This most extraordinary rise was in part attributable to local causes. The county bridge at this place is located just above the site of the factory, on a curve of the stream, as in the

annexed diagram, and although it has three arches of the usual span, it does not afford a sufficient vent for the water in time of a heavy freshet; and

at the present one, the passages became early obstructed with drift wood, and the arches quite choked up, so that the bridge which is more than twenty feet high, formed a dam across



the channel of the stream, and turned the whole body of the current against the factories. These factories stood in a contracted valley or pass, between high banks—the bridge occupying two-thirds of its entire width. Thus but a small space was left to vent the swollen stream, until it rose so high as to pass over the top of the bridge. Had the bridge given way early, in all probability the factories would have remained. As it was, the large factory did not sink until the water had reached its highest point, and had begun to fall. When the large factory went down, the roof remained entire while in view of those who witnessed its fall, the undulations of the current being sufficient to cause the factory bell in the cupola to toll the knell of its own sad catastrophe.* The bridge at this place was completely stripped of its guard-walls, but the arches remain standing.

The flood proceeded onward with uncurbed fury, uprooting and carrying with it trees of a large size, and almost every thing else within the scope of its resistless current. The flour mill of J. & I. P. Dutton, which had stood the better part of a century, was wholly carried away, with its valuable contents of grain, &c. Their saw-mill, barn, and wagon-house, with their contents, also shared the same fate. Their dam was partly carried away, and their race considerably injured. The flood passed through their dwelling house, and cleared two rooms of their furniture. In fact, with the exception of the dwelling house, this property was nearly left

* More than fifty persons, most of them females, were employed at Knowlton mills. The flood occurred on Saturday afternoon, after operations had been suspended for the week, agreeably to the regulations of that establishment, and the hands had all retired to their dwellings. Had the sudden rise in the water occurred earlier in the day, or had it occurred upon any other working day of the week, scarcely a doubt can exist, but that the lives of the whole number of persons employed in the factory would have been lost. Even if time had been afforded them to escape from the factory, the substantial character of the building would have prevented them from doubting the security of their situation, until every possible chance of retreat had been cut off.

in a state of nature ; presenting even a more wild appearance than it could have exhibited before the first improvement was erected upon it. The county bridge at Dutton's was almost wholly carried away, leaving nothing but one damaged abutment, and a very small portion of the other remaining. The greatest height of the flood at this place, was thirty feet six inches, as given by Mr. Jonathan Dutton, and the time of its greatest height about seven o'clock.

By a series of measurements made near these mills, by Professor John F. Frazer (who happened to be at the farm of Samuel West, a mile below, at the time of the flood) the cross section of the flood was found to be about seven thousand square feet. The point at which Prof. F. made the above measurements the flood attained a height of 25.16 feet—the creek being flush of water at the time.

Professor Frazer made a very accurate measurement of the flood on the farm of Mr. West. The following particulars in relation to which are extracted from a letter which that gentleman had the kindness to send in answer to the circular of the committee. "The height of the flood I measured with as much accuracy as my means would permit, and am confident that my measures are correct within one or two inches, at the same time I must observe that the elevations are taken above the level of the creek, a day or two after the flood, when from the continuance of wet weather, the creek was still above its ordinary level ; how much it is impossible for me to say. At the position where I first measured it, (upon Mr. West's upper meadow) the creek was about sixty feet wide, and averaged about six feet in depth, (it is the upper end of the back water from Flower's dam). The vertical height of the flood was 20.58 feet above the water line, or 26.5 feet above the bottom of the channel of the creek. The breadth of the water line at the highest point of the flood (measured at right angles to the direction of the creek) was 534.8 feet, (say 535 feet). The meadows overflowed, on either side, are quite flat, and appear to have been at some

former time, the banks of the stream or current, so that, I think we may assume the area of the cross section as at least two-thirds of the rectangular area given by multiplying the breadth by the height. Assuming then the numbers 535 and 21 as representing these (neglecting the channel actually occupied by the creek) we shall have the area of the cross section 7490 square feet. Assuming the creek to be sixty feet wide and six feet deep, and its cross section a rectangle (as it is very nearly) we have an area of 360 square feet for the creek at its ordinary high water, by which we see that the cross section was increased twenty times. The increase of velocity I had no means of ascertaining, as the greater breadth at this point gave rise to the formation of extensive eddies." It was not intended by the foregoing comparison between the cross section of the flood and that of the creek, to establish any proportion between the quantities of water which passed in a given time, during ordinary low water, and at the time of the flood. The measurements were made at the head of a dam, and during a time of flush water; besides it is probable that the velocity was ten times greater during the flood than at the ordinary stage of the stream. Professor Frazer is of opinion that at Mr. West's (judging from the motion of the cotton bales) the velocity of the middle of the stream was not less than from fifteen to twenty miles per hour.

At the farm of Mr. West, the creek makes a westerly curve, and the race from Flower's dam is taken out and carried down near the foot of the slope on the east side of the valley of the creek. The space between the creek and the upper end of the race was covered with standing trees. Some of the trees in this grove were uprooted or broken off, but the bulk of them remained firm, and formed a general lodgment for floating materials from above. About one hundred trees of various sizes brought down the current, found a resting place on this small piece of ground, besides timber from the wrecks of buildings, together with broken furniture, and parts

of machinery in immense quantities. The trunks of some of the largest trees lodged at this place, measured two feet six inches in diameter.

We are informed by Professor Frazer, that at Flower's mill, the flood attained its greatest height at eight o'clock and forty minutes, a point ascertained with some accuracy, while watching with serious anxiety an opportunity of rescuing Mr. William G. Flower. Mr. F. was rescued at half past nine o'clock, at which time the flood had fallen ten feet.

The flour mill and saw-mill belonging to the estate of Richard Flower, deceased, were both considerably injured—the latter removed from its former location. The lattice bridge near these mills, built but a few years since at a heavy expense to the county, was carried away, and both of the abutments injured. The railroad bridge at Chester, was carried off, together with an extensive portion of the embankment, on the western side of the creek. This bridge bent sidewise, nearly its whole width, before the ends were carried from the abutments. The chain suspension bridge at Chester, was also carried away. It did not yield, however, until it had resisted the force of the current, and the battering of drifting trees and timber, for a long time. The western abutment was razed to its foundation, and swept away, and the earth was torn up several feet below the foundations of the wing-walls. The eastern abutment was also injured.

The damage done to private property by the flood in the borough of Chester, was also very considerable. Samuel Lytle had a fine row of basket willows uprooted and carried away, also his crane for loading large stone from his quarries. Captain Pierson's wharf was partly carried away, as was also that belonging to the estate of Captain John Hart. J. P. & W. Eyre had their storehouse injured, their crane carried away, and about two hundred tons of coal swept from their wharf. William Eyre, Jr. had his stock of lumber floated off, and his new wharf greatly injured. The store of Jesse M. Eyre was badly flooded.

William Kerlin had his stone kitchen, and several out buildings with their contents, carried away, the main building injured, and the furniture in the basement destroyed. William Kerlin, Jr. had a frame house carried off and entirely destroyed, as was also the slaughter house of William McCafferty, deceased. William Brobson's tan yard was much injured; his lime house was carried off, and his loss in hides and bark was very considerable. William Benton, who occupied the house of William Kerlin, Jr. had all his household goods, dearborn, cart, &c., carried off. Mrs. Mary Engle's sheds and stables, occupied by Maurice W. Deshong, were much damaged. The pattern house connected with the foundry of Jacob G. Kitts was carried away, together with nearly his whole stock of valuable patterns.

Agricultural interests suffered severely along Chester creek and its tributaries. The meadows and flats were every where stripped of their fences. Few of these flats were under tillage, consequently the losses in crops, except grass, were not very great, but in some places whole acres present deep deposits of sand and gravel, and in others the surface is deeply excavated, or covered with rocks and stones, and rendered wholly unfit for culture, or even for pasturage. Joseph Griffith, Richard Dutton, Isaac Morgan, Nathan Suplee, Robert McCay, John Slaughter, and Aaron Wood are among this class of sufferers.

It will now be seen that the flood in Chester creek was much higher than in either of the other large streams. This increased swell evidently depended on the immense quantity of rain which fell in a short time, within the drainage of its more westerly branches, as the water in the main East branch was not higher a short distance above its junction with the West branch, than Ridley creek, at a corresponding point. It will also be seen, that the damage to private property was immensely greater than upon either of the other large streams.

(*To be continued.*)

MINUTES OF THE INSTITUTE.

AUGUST 4, 1910.—Regular monthly meeting, President T. Chalkley Palmer in the chair. Reports of committees and routine business. The insect called the "walking stick" was shown as an example of protective mimicry. Dr. J. C. Starbuck exhibited under the microscope *Amœba dysenterica*, of especial interest in its apparent peculiar protoplasmic structure. T. Chalkley Palmer spoke of the so-called reticulated structure of protoplasm. After further discussion, the opinion was reached that the reticulated structure of protoplasm could scarcely be disputed. Adjourned.

SEPTEMBER 1, 1910.—Regular monthly meeting, with Vice President Henry L. Broomall in the chair. Reports of officers and routine business. The following contributions to the library were announced:—"A New Diatom," by T. Chalkley Palmer; "The Age of the Earth," by George F. Becker; "Preliminary Study of Chemical Denudation," Clarke. C. M. Broomall gave a talk on the subject of "Waves." After discussion the meeting adjourned.

OCTOBER 6, 1910.—Regular monthly meeting, President T. Chalkley Palmer in the chair. Reports of committees and routine business. The following purchases were added to the library: "Protozoology," by Calkins; Herting's "Manual of Zoology," translated by Kingsley. Announcement was made of the death, on October 5th, of our esteemed fellow-member, Charles Potts, in the 85th year of his age. Henry L. Broomall and C. Edgar Ogden were appointed to draft resolutions sensing the great loss the Institute has sustained. T. Chalkley Palmer reported that the waters of Delaware river were yielding much more than the normal quantity of salt, attributable to lack of rainfall in the basin of that stream. Adjourned.

OCTOBER 13, 1910.—Adjourned meeting. Lecture, "The Chemistry of Diatoms," by T. Chalkley Palmer.

OCTOBER 27, 1910.—Adjourned meeting. Illustrated lecture, "Geographical Cryptogams of 1910," Dr. A. F. K. Krout.

MINUTES OF SECTION A.

AUGUST 11, 1910.—The stated subject, "Flora and Fauna of a Town Lot," led by Sanford Omensetter, was the topic of the evening.

AUGUST 18, 1910.—Stated subject, "Animal Heat" led by Dr. J. Clinton Starbuck.

AUGUST 25, 1910.—C. Edgar Ogden exhibited *Nitella* collected in Media, and discussion followed.

SEPTEMBER 8, 1910.—Stated subject for discussion, "Climbing Plants," led by C. Edgar Ogden.

SEPTEMBER 15, 1910.—C. Edgar Ogden showed a colony of a low form of life [*Laguncula repens* (?)] found growing on rocks in Broomall's dam, in Media. Dr. Harold C. Barker exhibited a fine collection of seaside plants from Avalon, N. J. C. M. Broomall spoke of some Media water, bottled last year, which had produced vegetation. A. S. Barker drew attention to the phosphorescence of jelly fish when placed in a containing vessel.

SEPTEMBER 22, 1910.—A. S. Barker showed interesting seaside specimens, including barnacles, piece of dogfish skin, *Campanularia* showing calycle from which buds evolve, seaweed species in fruit, species of sponge, etc. Stated subject, "Local Ferns," led by T. Chalkley Palmer.

SEPTEMBER 29, 1910.—Stated subject, "Crotalus Venom," led by Dr. J. C. Starbuck.

OCTOBER 20, 1910.—C. M. Broomall spoke on fermentation, illustrated by experiments. Dr. B. M. Underhill exhibited a leaf of the ginkho tree, and drew notice to the tree's descent from ancient geologic time. The yeast plant was shown under the microscope by Albert S. Barker.

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Vol. VI, No. 2

January, 1911

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OF THE
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INSTITUTE OF SCIENCE

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PROCEEDINGS

OF THE

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VOL. VI, No. 2

JANUARY, 1911

AN UNUSUAL FORM OF MAIZE.

BY JOHN W. HARSHBERGER, PH. D.

The specimen of corn described below was grown on the premises of Dr. Horace Howard Furness, of Wallingford, Delaware county, Pa., in 1910, from seed obtained from the field corn of James Miller, whose farm is in the neighborhood. An examination of it shows a centrally placed axis, or cob, which is a continuation of the main stem of the plant. This axis is about six inches long, with twelve rows of pistillate flowers, that had already begun to mature their fruits (corn kernels, or caryopses) which are somewhat pointed at the extremity, bearing a single thread of silk. Each spikelet in this flower cluster bears only one perfect flower; the other one is rudimentary, and, like ordinary field corn, is not represented. The terminal part of this central ear, or spike, is occupied by about twenty to twenty-five male spikelets, each spikelet of two flowers, and each flower with three normally developed stamens. Several of the developing grains on one side of the central ear are smutted with the smut fungus, *Ustilago maydis*. Arising from the base of the central axis are four other axes, or ears, which are more slender than the central one, and three of them have the separate spikelets arranged in a two-ranked (distichous) manner. The fourth one is irregularly three-ranked, suggesting at its tip a two-ranked condition. The lower spikelets of these more slender

ears, or branches, consist of two perfect, pistillate flowers, a probable reversionary condition, because the number of glumes, or scales, calls for two flowers. In ordinary maize, only one of these flowers is perfect; the other is absent. Each of these separate flowers reveals a partially developed ovary, or fruit. The terminal part of two of the secondary flower spikes is entirely made up of spikelets of two male flowers, so that we have in all of the spikes, large and small, what botanists are pleased to term the androgynous condition, where male and female flowers are on the same floral axis, but in different parts of it. These ears are not inclosed by husks, but at the base of the cluster are small, green leaves, consisting of the usual parts, viz.: sheath, ligule and blade.

This abnormal specimen strengthens the conclusion reached by me in 1893, that the ear of corn is an altered branch. The leaves of the branch have their blades almost entirely absent, and the ligule also is missing. These leaf bases, or shields, form the husks which surround the ear of ordinary corn, and between which at the top the threads of silk protrude. Occasionally in field corn we get two or three smaller ears tucked away between the husks that cover the larger, central ear. This condition of branched ears, which in several cases bear two-ranked spikelets, suggests the branched, two-ranked ears obtained when ordinary black Mexican field corn is crossed with teosinté (*Euchlœna mexicana*), and which I described some years ago in *Garden and Forest* (ix: 522), and also in *Contributions from the Botanical Laboratory of the University of Pennsylvania* (1901). In *Bailey's Encyclopedia of American Agriculture* (Article Maize), I refer to the theory of Montgomery, who believes that in the process of evolution the cluster of pistillate spikes in teosinté were developed from the lateral branches of a tassel-like structure, while the corn ear developed from the central spike. It is probable, according to Montgomery, that the progenitor of teosinté and maize was a large, much-branched grass, each branch being terminated by a tassel-like structure, bearing

hermaphrodite flowers. This, I think, is purely speculative. In referring to my notes on corn, I find three references which are of interest in comparing them with the unusual form of plant found on the grounds of Dr. Furness. The first (Science, Sept. 29, 1883) was a stalk of corn found at Freeport, Illinois, by O. H. Hershey, in which the stalk failed to develop any ears in the axils of the leaves, but instead a single spike of pistillate flowers (an ear) at the end of the central pedicel of the tassel. This ear was about three inches in length, and apparently well formed, except that it lacked the glumes. The styles were perfectly developed, and six inches to a foot in length. The places of a few of the grains were occupied by staminate flowers. The second, "Queer Growth of Corn" (St. Nicholas, March, 1909, p. 462), was found at Upper Montclair, N. J., and was photographed to show a single median ear and two smaller lateral ones. The third case, found at Greenport, New York, was described in Meehan's Monthly (Nov., 1895, Volume V), and the suggestion there made by Mrs. Kellerman is perhaps the safest conclusion which may be reached as to these three unusual forms of corn, including the one found on the demesne of Dr. Horace Howard Furness, at Wallingford. Mrs. Kellerman is quoted as follows:— "I would say that the primitive Indian corn was a grass-like plant with a branch springing from the several nodes or joints. Each branch was crowned with both staminate and pistillate organs. Natural selection lifted the staminate flowers to the tassel of the main stalk, and left the pistillate below on the side branches. These branches became shortened, and form the shank or footstalk of our present ear." The leaves also became crowded to form the overlapping husks. I would present as my conclusions of the study of maize a somewhat different description of the original wild form of corn, based on a study of the normal and abnormal conditions.

The original corn was a tall, semi-tropic grass, with broad, two-ranked leaves, in the axils of which were found

branches bearing lateral axes, with pistillate spikelets of two flowers each below, and staminate two-flowered spikelets above. Through extensive cultivation, the lower branches being more generously nourished, developed ultimately only pistillate flowers, the male flowers being crowded out, or suppressed, by the two-ranked, pistillate spikelets. The terminal part of the plant, originally an androgynous spike, because of its position, tended toward the suppression of the pistillate spikelets until the terminal axis came to bear only staminate flowers. These are produced in pairs in each separate male spikelet, as in the original condition, while in the cultivated corn, by a crowding of the spikelets together, one of the pistillate flowers has become rudimentary. The structure of this abnormal specimen suggests this, and the view is strengthened if we compare it with ordinary corn, with teosinté, and with the closely related gama grass (*Tripsacum dactyloides*), where the pistillate flowers and the staminate flowers are borne on the same axis of inflorescence and in a two-ranked fashion. All of this is pure speculation, but we have now reached the place in our methods of breeding, where I think the test of all our theories can be made. If we study the phenomena of reversion, we find that in most cases such reversion occurs when two varieties which are crossed each contain certain factors lacking in the other, of which the full complement is necessary for the production of the reversionary wild form. This at once suggests the idea that the various domestic forms of animals and plants have arisen by the omission from time to time of this factor, or of that. Nevertheless there are other cases where we must suppose evolution to have proceeded by the addition of characters. So that domestic varieties may arise by a process of addition of factors in some cases, and of subtraction in others. In the domestication of corn, it has been the suppression of male flowers on the lower branches and the multiplication of pistillate ones, while on the terminal axis the pistillate flowers have been subtracted and the staminate ones

increased. From experimental breeding work done on the sweet pea, where it has been determined that from the wild, purple, bicolor type of flower, we have at least six types of colored flower forms, we have at our command experimental methods by which we can determine the character of the original wild progenitor of maize.

University of Pennsylvania.

THE FLOOD OF 1843.

(*Concluded.*)

It has already been observed that the Brandywine was not much raised. One of its tributaries, however, partly within the borders of this county, was raised to an inordinate height, and was productive of considerable damage. This stream is called Beaver creek, and in its course crosses the circular line which divides this county from the state of Delaware more than once. The first mill on it is a saw-mill belonging to Reece Perkins—his dam was broken, and his race was injured, but his loss was not heavy. The next mill below was in the state of Delaware. It was a stone woollen factory, owned by Charles Dupont, and occupied by Lewis Sachriste. So much of this factory building was washed down, that it may be considered as a total loss. The dam, which was very large, was entirely swept out, and all the machinery, stock, &c., in the mill, was washed out, and carried off. The loss to Messrs. Dupont & Sachriste, was very heavy. The meadow of Nathaniel Newlin, below this dam, was damaged to the amount of two hundred dollars. Next below, the dam of Philip Hizer's woollen factory was all taken away, and the race washed out. Opposite to Hizer's, but over the State line, J. Chandler's smith shop, was swept off with its contents—the water here rising eight feet above its usual level, and four feet higher than the flood of 1795, and according to tradition, the same height above a flood which is said to have occurred in 1740. The smith shop was standing in 1795, and had a mark on it showing the height of the flood of that year. Next below Hizer's factory is the paper mill of Daniel Farra. The dam was taken away, with a considerable amount of personal property. The water here was ten feet above its usual level. Mr. Farra had a dam on a small stream which empties into Beaver creek, which was also carried away. Higher up on this branch the dam and race of Mr. Morrison's smithery was broken. Next below Mr.

Farra's paper mill, is the upper flour mill of Isaac Smith. This mill is in Delaware state, but the dam is in Delaware county. The dam was carried away to its foundation. The water here was twelve feet above its usual level, and was at its greatest height about four o'clock.

Thomas Brinton and Joseph P. Harvey, on another tributary of the Brandywine, in the northern section of Birmingham, near the State road, had their mill dams broken, but the committee have been unable to learn the amount of their losses. This stream was higher than ever before known.

Naaman's creek was also very high, caused principally by the heavy rain in the neighborhood of its head waters. Col. Thomas Robinson had a small barn with a quantity of hay carried off, and Mr. Churchman lost a quantity of lumber, logs, &c. by the flood in this stream. Some other damages occurred on this creek, but the amount was inconsiderable.

On Shellpot run, a small tributary of the Brandywine, a bridge was carried away, valued at five hundred dollars. The losses occasioned by the flood in Brandywine hundred, Delaware state, may be set down as follows :

Messrs. Dupont & Sachriste,	-	-	-	-	\$3,000
J. Chandler,	-	-	-	-	100
Isaac Smith,	-	-	-	-	1,000
On Naaman's Creek,	-	-	-	-	1,200
Damage to fences, meadows, &c.,	-	-	-	-	1,500
Bridges,	-	-	-	-	600
					<hr/>
					\$7,400
					<hr/>

The Gulf creek, which it will be recollected empties into the Schuylkill, rose to an undue height, and was productive of considerable damage. But a small part of this stream is in Delaware county—but one mill and one county bridge, and consequently but little damage was sustained either by individuals or the public. This, however, was not the case beyond the limits of the county. In Montgomery county the

damages on this small stream were very considerable. Four mill dams were swept out, and one bridge destroyed, and another considerably injured, besides heavy damages sustained at several mills and factories. The following list of damages on this stream, within the borders of Montgomery county, was furnished by Perry M. Hunter, Esq., to a member of the Institute, and by him communicated to the committee :

County, one bridge destroyed,	-	-	-	\$800
County, one bridge damaged,	-	-	-	100
				<hr/>
				\$900
				<hr/>
Damage to Mrs. R. Thomas' flour mill,	-			\$ 400
“ J. Freedly's flour mill,	-			200
“ Bethel Moore's upper factory,	-			1,000
“ George McFarland's factory,	-			300
“ B. Moore's Baligomingo factory,	-			1,000
“ Mr. Leonard's marble saw-mill,				500
				<hr/>
				\$3,400
				<hr/>

Besides the above, some damages occurred at other points beyond the borders of Delaware county, but nothing of a very serious character so far as the committee have been informed. Our little county appears to have been destined in a peculiar manner, to bear nearly the whole brunt of the calamity. The shock was so sudden and so violent, that for a few days the people stood aghast, almost ready to believe that their county had been overwhelmed in irreparable ruin. This feeling, however was of but short duration. Their recuperative energies were soon brought into full play, and already much of the injured property has been restored to its former condition, and in many instances the new works are in every respect superior to those which they are intended to replace. It is now apparent to every one, that but a few years of pros-

perity will be required to replace the county, in every respect, in the same enviable position which she has so long enjoyed.

As large as was the amount of property destroyed, the poor were the heaviest sufferers in proportion to their means. "Twenty families had their houses with their contents carried away, and more than one hundred other families met with severe losses, in proportion to their means, by the destruction of furniture, household utensils, provisions and other necessities, that render the abode of the poor man comfortable. Among these were twenty-one widows with families containing fifty-two children."* The first efforts of our people were turned to the relief of these indigent sufferers. In this they were liberally aided by the city and county of Philadelphia, and the county of Chester. The sum of three thousand three hundred and seventy-five dollars and seven cents was contributed, and placed in the hands of a general committee raised for the purpose of receiving and making distribution of the same. From this fund the committee have been enabled to extend aid to one hundred and thirty-one families, including four hundred and four children. Independent of this fund, considerable amounts have been contributed in different neighborhoods, expressly for the relief of particular sufferers.

The buildings which were carried away, and those wholly or nearly destroyed, if placed contiguous to each other, would constitute a considerable village. In this connection may be enumerated thirty dwelling houses, eight manufactories of different kinds, two flour mills, three saw mills, two paper mills, besides twenty other buildings of various descriptions. In addition to these, fifty-three mill dams were either entirely swept out, or very much damaged. In fact scarcely a mill property on the inundated streams escaped without injury to some extent, and besides the buildings above enumerated, very many were seriously injured. It was the original intention of the committee, to have furnished an estimate of the

* Report of the Relief Committee.

loss of each description of property, but from the returns made to them, they will be obliged to adopt a different course. The loss of each individual (as furnished to them) will be presented in the aggregate. So far as the agricultural interest of the county is concerned, no estimate of individual losses will be given, although in some instances it was very severe. The destruction of crops and fences, and the ruin of meadow lands are so wide spread, and embrace so many individual cases as to forbid the committee from attempting more than a general estimate, which they feel well assured is rather below than above the amount of this kind of damage which was actually sustained.

Thirty-two of the county bridges were either wholly destroyed, or seriously injured. It will be seen by the following estimate, carefully made by competent persons, that it will require an expenditure of twenty-four thousand, seven hundred and twenty dollars to repair or rebuild the several bridges within the county, which were damaged or destroyed by the freshet :

<i>Darby Creek.</i> —Darby bridge,	-	-	-	\$2,000
“ Turnpike bridge,	-	-	-	250
“ West Chester road bridge,	-	-	-	60
“ Leedom’s bridge,	-	-	-	60
“ Hood’s bridge,	-	-	-	1,000
<i>Ithen Creek.</i> —Radnor Meeting House bridge,				475
<i>Crum Creek.</i> —Leiperville bridge,	-	-	-	25
“ Leiper’s bridge,	-	-	-	250
“ Riddle’s Factory bridge,	-	-	-	400
“ Lewis’ dam bridge,	-	-	-	2,500
“ Beatty’s bridge,	-	-	-	1,000
“ Holland’s bridge,	-	-	-	250
“ C. Palmer’s mill bridge,	-	-	-	50
“ Bartram’s bridge,	-	-	-	400
“ Howard’s bridge,	-	-	-	1,000
“ West Chester road bridge,	-	-	-	1,000
<i>Ridley Creek.</i> —M’Ilvain’s bridge,	-	-	-	700

<i>Ridley Creek.</i> —Crosby's mills bridge,	-	\$	75
“ Crosby's dam bridge,	-		3,000
“ Sharpless' bridge,	-		100
“ Dr. Young's bridge,	-		450
“ Edward Lewis' bridge,	-		200
“ Bishop's mill bridge,	-		800
“ Russell's bridge,	-		75
<i>Chester Creek.</i> —Chester bridge,	-		2,150
“ Flower's mill bridge,	-		800
“ Dutton's mill bridge,	-		1,000
“ Knowlton bridge,	-		300
“ Rockdale bridge,	-		1,000
“ Lamott's bridge,	-		1,300
“ Grubb's bridge,	-		250
“ Crozer's bridge,	-		1,000
“ Tyson's mill bridge,	-		800
			<hr/>
			\$24,720
			<hr/>

It must not be inferred that the above sum will cover the whole county loss in the way of bridges. The water ways furnished by the arches of nearly all of our stone bridges were wholly inadequate, in the time of a high freshet, and in most instances where these arches have been swept out, economy, as well as prudent foresight, suggests the propriety of supplying their places with wooden structures. This plan of rebuilding these stone bridges, has been adopted in some instances, and it is understood, will be adopted in others. By pursuing this course the present cost will be greatly diminished, but the permanency of the structure (every other cause of destruction and decay considered, except high freshets,) will not compare with the stone arches which it is intended to supply. In other instances where the extended wings of a bridge have been carried away, but a small part of them will be rebuilt, in order that they may present less obstruction hereafter to the passage of high freshets. The road way will

not be quite so good, but the safety of the bridge will be promoted. The real amount of loss to the county, cannot, therefore fall much short of forty thousand dollars.

The damage sustained by some of the townships in the destruction of small bridges and culverts, and in the tearing up of the roads, was very considerable. A moderate estimate will make this item of loss amount to the sum of three thousand dollars for the whole county.

The following list of individual losses on the several inundated creeks has been principally made out from the estimates furnished by the individuals themselves, or from persons residing in the vicinity of the places where the losses occurred. In a few instances, it is probable these estimates are too high, while in others they are believed to be below the amount actually sustained. The aggregate amount will vary but little from the truth.

On Darby Creek and its tributaries.

William Crossley,	-	-	-	-	\$	300
Samuel Moore & Co.,	-	-	-	-		500
Levi Lewis,	-	-	-	-		
Clement & William P. Lawrence,	-	-				300
Moses Hey,	-	-	-	-		100
Palmer & Marker,	-	-	-	-		1,300
Oborn Levis,	-	-	-	-		1,000
John & Thomas Kent,	-	-	-	-		1,800
Estate of Thomas Garrett,	-	-	-	-		3,000
D. & C. Keily,	-	-	-	-		1,000
M. Nolan,	-	-	-	-		100
Estate of Asher Lobb,	-	-	-	-		700
M. Matthews,	-	-	-	-		1,500
Estate of Joseph & James Bonsall,	-					300
Thomas Steel, Sen'r,	-	-	-	-		400
Thomas Glascoe and others,	-	-	-	-		400
John Moore,	-	-	-	-		100
William Serrill,	-	-	-	-		150

Jesse Brooke,	-	-	-	-	-	\$ 200
John Evans,	-	-	-	-	-	350
Other persons not enumerated,	-	-	-	-	-	1,500
Agriculturalists, in crops, fences, and injury to meadow lands,	-	-	-	-	-	5,000
						<hr/>
						\$20,000

On Crum Creek and its tributaries.

Jonathan N. Hatch,	-	-	-	-	-	\$ 500
A. & E. Williamson & S. Bishop,	-	-	-	-	-	100
T. C. Palmer,	-	-	-	-	-	550
John C. Beatty,	-	-	-	-	-	4,500
John & George Lewis,	-	-	-	-	-	2,500
William J. Leiper,	-	-	-	-	-	2,500
James Riddle,	-	-	-	-	-	5,000
Hon. George G. Leiper,	-	-	-	-	-	2,000
Samuel Beard,	-	-	-	-	-	350
Sundry other persons, in small amts., not enumerated						1,000
Damage to Agriculturalists, in crops, fences and injury to meadow land,	-	-	-	-	-	5,000
						<hr/>
						\$24,000

On Ridley Creek and its tributaries.

Amor Bishop,	-	-	-	-	-	\$1,300
Edward Lewis,	-	-	-	-	-	2,500
Thomas Hutton,	-	-	-	-	-	800
Samuel Bancroft,	-	-	-	-	-	6,500
C. Sherman & E. Taylor (both Mills,)	-	-	-	-	-	15,000
Parke Shee, Esq.	-	-	-	-	-	1,500
J. G. Johnson,	-	-	-	-	-	400
John M. Sharpless (and others)	-	-	-	-	-	1,300
Enos Sharpless,	-	-	-	-	-	400
Peirce Crosby, Esq.	-	-	-	-	-	1,000
Edward R. Crosby,	-	-	-	-	-	400

Other persons in small amounts, not enumerated	\$2,000
Agriculturalists, in crops, fences, and injury to meadow lands, - - -	6,000
Whole amount on Ridley creek, - - -	<u>\$39,000</u>

On Chester Creek and its branches.

Estate of John Edwards, Esq. - - -	\$ 800
James M. Wilcox, - - -	1,200
Abraham Sharpless, - - -	
Estate of Thomas Thatcher, - - -	500
David Green, - - -	100
Humphrey Yearsley, - - -	100
Joseph Pennell, - - -	50
D. Lamott & Son, - - -	3,000
Hannah S. Hill, - - -	3,500
Caleb Brinton, - - -	400
Matthew Ash, - - -	100
C. W. Sharpless, Esq. - - -	500
Joseph M. Trimble, - - -	100
Samuel F. Peters, - - -	1,000
James S. Tyson, - - -	1,500
John P. Crozer, - - -	45,000
Samuel Riddle, - - -	3,000
Richard S. Smith, - - -	3,000
George Peterson, - - -	700
Estate John Rhoads, - - -	1,200
James Dixon, - - -	1,000
J. & I. P. Dutton, - - -	6,000
Estate of Richard Flower, - - -	1,000
William G. Flower, - - -	2,000
Samuel Lyttle, - - -	500
Estate of Capt. Peirson - - -	200
Estate of William M'Cafferty, - - -	150
Estate of Capt. John Hart, - - -	300
J. P. & W. Eyre, - - -	1,500

William Eyre, Jr.,	-	-	-	-	\$2,500
Jesse M. Eyre,	-	-	-	-	1,000
William Kerlin,	-	-	-	-	1,500
William Kerlin, Jr.,	-	-	-	-	225
Mary Engle,	-	-	-	-	400
William Brobson,	-	-	-	-	2,000
William Benton,	-	-	-	-	150
Jacob G. Kitts,	-	-	-	-	5,000
Other persons in small amounts,	-	-	-	-	2,500
Agriculturalists, in crops, fences, and injury to meadow land,	-	-	-	-	10,000
Whole amount on Chester creek,					<u>\$104,775</u>

On tributaries of the Brandywine.

Reece Perkins,	-	-	-	-	\$ 50
Philip Hizer,	-	-	-	-	200
Daniel Farra,	-	-	-	-	550
Isaac Smith, (in Penn'a.)	-	-	-	-	300
Other persons,	-	-	-	-	500
Crops, fences, &c.,	-	-	-	-	1,000
					<u>\$2,600</u>

Amount of private loss on Darby creek,	\$ 20,000
Do Crum creek,	24,000
Do Ridley creek,	39,000
Do Chester creek,	104,795
Do Tributaries of Brandywine,	2,600

Whole amount of private loss,	-	-	190,375
Do to the county,	-	-	40,000
Do to several townships,	-	-	3,000
Do to the Phil. Wil. and Balt. rail road Co.			4,500

* Whole amount of loss caused by the flood, \$237,875

The time at which the flood in Darby creek attained its maximum height, was from half an hour to an hour later than in the other creeks. The difference in those streams does not appear to have been considerable. The greatest height of the flood in Darby creek was seventeen and a half feet ; in Crum creek twenty feet ; Ridley twenty-one feet, and Chester thirty-three feet.

A large freshet occurred in this county in the year 1795, another in the year 1822, and another (probably still larger) in the year 1839, but neither the memory of man, nor tradition affords any evidence of a flood that would bear a comparison with that of the 5th of August last. Neither were any traces to be found along the vallies of the streams (similar to those now to be seen, particularly along Chester creek) to justify the belief that the county had been subjected to such a visitation, during a period of many centuries.

We are informed by Mr. Enos Sharpless, that the flood of 1795 gave rise to a good deal of speculation at the time, as to the cause why there should be higher freshets than had formerly been. Some attributed it to the land having become more cleared, affording the water a better chance to run off, others appeared serious in attributing it to the introduction of plaster of Paris and its tendency to attract moisture ; but all agreed that the freshet of that year was the highest that they had ever seen, and as there were people then whose recollection would extend back fifty or sixty years, Mr. S. thinks we may safely conclude that that freshet continued to be the highest until the freshet of 1839, which was one foot higher, and now he remarks, " we have one in 1843, seven feet three inches higher than that." It must also be observed that the

(Foot note from preceding page). * By adding to the above estimate of losses by the flood, that which was caused by lightning, and that caused by the wind in prostrating orchards and forest trees, the amount of private loss will not be less than \$200,000 dollars, within the borders of Delaware county, and the aggregate of public and private losses will not fall short of a quarter of a million of dollars.

quantity of water passing down increases in a ratio much beyond the increase of depth, as the cross section of the valley of the creek increases as the flood rises, and the velocity of the current is also greatly accelerated by its increased depth. It is probable, therefore, that the quantity of water which passed the mills of Mr. Sharpless in a given time in the flood of 1843, was much more than double that of 1839, and if the comparison were made on Chester creek, it would probably quadruple that flood in the quantity of water which passed in a given time.

LOSS OF LIFE AND RESCUES FROM DROWNING.

The most melancholy part of the duty of the Committee consists in recording the circumstances connected with the sacrifice of human life, which was occasioned by the flood. Nineteen individuals, most of them children and young persons, were suddenly, and almost without warning, deprived of their lives; and this too, under circumstances peculiarly distressing to their relatives and friends. To persons who cannot bring their minds to realize the almost instantaneous rise in the waters, the number lost by drowning may appear large, but in reality it should be regarded as almost miraculous, that so small a number should have perished. The numerous hair-breadth escapes and rescues from the most perilous situations, will sufficiently show what trivial circumstances prevented the number from being very greatly increased. Had the inundation occurred at midnight, when most persons are wrapped in slumber, the destruction of human life would have been dreadful indeed. Such a calamity can only be contemplated with feelings of horror.

Seven lives were lost on Darby creek. When the stone bridge at Darby yielded to the torrent, two young men—Russell K. Flounders and Josiah Bunting, Jr., were standing upon it. Both perished. The body of the former was carried

by the current to the meadows, a distance of two miles, where it was found after four days search; the body of the latter was engulfed amid the wreck of the masonry of the bridge, and was not discovered until the lapse of two weeks, though the most diligent search had been made. Mr. Flounders was in the twenty-first year of his age, and Mr. Bunting in his nineteenth. Both of these young men gave great promise of future usefulness, and their early and melancholy death proved a severe trial to their numerous relatives and friends. Several persons had left the bridge but a short time before it gave way.

At the cotton factory occupied by D. & C. Kelly, on the New London turnpike, five lives were lost. A frame tenement stood immediately below the western walls of the bridge, and between the factory building and the creek. This dwelling was occupied by Michael Nolan and his family, consisting of his wife, five children, and a young woman named Susan Dowlan. Before any immediate danger from the rise in the water was apprehended, Michael and his eldest son had left the house with the view of making arrangements for the removal of the balance of the family. There was no water about the house when the father and son started upon their errand, yet upon their attempt to return, after an absence of less than five minutes, it was not in the power of any one present to reach it, much less to render the inmates any assistance. The wing walls of the bridge soon gave way. Shortly after this, the house was swept from its foundations—instantly became a complete wreck and all the inmates perished, with the exception of Susan Dowlan. Thus in the space of a few minutes, after they became aware that they were within the reach of danger, a mother and her four children were deprived of their temporal existence, leaving a disconsolate husband and father, and a son and brother to deplore their untimely fate. Julia Nolan, the mother, was thirty-eight years of age, and her children, whose names were James, Thomas, Michael, and Ann, were respectively aged fifteen, nine, five and three

years. All the bodies were found some distance below on the following day.

Susan Dowlan, the other member of this ill-fated family, had her life preserved under circumstances which scarcely presented one chance in ten thousand. As the water rose the inmates of the house retreated to the second story for safety, but it was not until the wing walls of the bridge gave way, that they realized the danger to which they were exposed. In less than half an hour after the yielding of the bridge walls, the house began to fall in pieces, and they were all precipitated into the roaring torrent. Being resigned to what she believed would be her inevitable fate, she commended herself to the mercy of her Maker; and while struggling in the water (to use her own expression,) "in the agonies of death," she made a grasp with the hope of seizing one of her more unfortunate companions, as she "dreaded to die alone." In this effort she caught hold of the branches of a tree, standing immediately on the margin of the channel of the creek, and, at length, obtained a foot hold on a knot which slightly projected from its trunk. This tree is about sixty yards from the site which the house had occupied, and a shorter distance from the arches of the bridge, from which, the water rushed with impetuous fury. Though the position of the knot kept her for a considerable time immersed in water up to her waist, she was in a measure shielded from the force of the current by the trunk of the tree. She remained in this position for the space of three and a half hours. No one on shore being able to render any assistance during that time, though they could distinctly hear her piteous cries for help. At length when the flood had somewhat subsided, Messrs. Charles McClure, John Cunningham and John Heller, made a praiseworthy effort to relieve her. They all crossed the rapid current which still swept round the bridge, and reached a position where the water was less deep, and within a short distance of the tree upon which Susan stood. At the risk of his life, Mr. McClure swam with one end of a rope and suc-

ceeded in reaching the tree just in time to save her from yielding her position, and consequently her life, from exhaustion. Securing the rope to her body, and by the assistance of Messrs. Cunningham and Heller, he was enabled to rescue her from a watery grave. Thus it will be seen that Susan Dowlan owes her life to a combination of circumstances which the most inventive imagination could scarcely have pictured to subserve the purposes of fiction.

At Garrett's factory, also occupied by D. & C. Kelly, three families, numbering sixteen individuals, were, for a long time placed in the utmost jeopardy. Their retreat to the land was wholly cut off by the sudden rise in the water. The houses they occupied were completely wrecked, and large portions of them carried away. They had nothing left but their tottering ruins to afford them the least security. These fortunately withstood the force of the current, though every individual had given up all hopes of surviving that dreadful night.

No lives were lost on Crum creek, nor are the Committee aware that any persons were rescued from situations of great peril upon that stream.

On Ridley creek five lives were lost—a father and his four children. George Hargraves, his wife and four children, resided at the factory of Samuel Bancroft. A long stone building which had been converted into four dwellings, stood in a very exposed situation between the factory and the steep acclivity on the west side of the creek. One of the middle dwellings was occupied by George Hargraves, his wife and five children, and William Hargraves, the brother of George. The other middle house was occupied by Thomas Wardel Brown, his wife and child. In endeavoring to secure the property in the basement of their dwellings, these persons delayed making their escape until all chance of doing so was gone, so sudden was the rise in the water at this place. They retreated to the second story of their house, and occupied one of the bed rooms—the water continuing to rise with fearful

rapidity, until at length it burst through the building carrying away the two middle dwellings, and with them George Hargraves, the father, and his four older children, into the destroying flood, but they were not immediately drowned. William Hargraves, when he found the walls of the house were yielding, plunged into the flood, and by this step not only succeeded in preserving his own life, but was placed in a situation to witness what befel his less fortunate brother and his brother's children, up to the time their lives were sacrificed to the impetuous fury of the flood. William supposes that part of the wall of the house struck him and carried him under the water, but he at length succeeded in reaching the surface, and was carried down by the current nearly half a mile, with the logs and drifting timber at times passing over him. At one time he thought he would not again be able to reach the surface, so long was he kept submerged by these floating materials. After catching in vain at every twig or branch which came in his way, he at length encountered a standing tree, to which he held, and was not afterwards subjected to further danger. When William reached this place of security, he supposes George and his children were about one hundred yards behind him. They, however, soon swept past him on a bed, George calling out as he passed, "hold on to it, William." Scarcely had George given this admonition to his brother, when he and his four children were swept from their position on the bed and engulfed beneath the turbulent waters of the flood, not to rise again. George Hargraves was aged 38 years, and his children, Sarah, Andrew, George and Samuel were respectively aged 13, 11, 9 and 6 years. Their bodies were found about a mile below, the body of the youngest child being clasped in the arms of its father. William Hargraves maintained his position in the tree during four hours when he was rescued and brought to shore by means of a rope. He says that during all the scenes of peril through which he passed, his presence of mind at no time forsook him for a single moment. Jane Hargraves, the wife (now widow

of George) at the time the flood burst through their dwelling was standing near the corner of the room with her infant child in her arms. This part of the floor (but a few feet square) and this only remained. Upon these projecting boards this woman with her child stood for the space of nearly five hours, when she was rescued by Mr. Thomas Holt. Thomas Wardell Brown, his wife and child, occupied a corresponding part of the floor of his dwelling, but of scarcely half the dimensions of that upon which Jane Hargraves stood. They also were standing upon this part of the floor, when the flood burst through their dwelling, and *this was the only portion of it which was not carried away*. They were rescued about the same time as Jane Hargraves. It would be difficult to describe the feelings of people under such circumstances, particularly those of Mrs. Hargraves, who just before had seen her husband and all her children, except the infant in her arms, borne away from her on the bosom of the flood.

About eighty yards above Sherman's upper factory, a double frame house was occupied by William Toombs and James Rigley, with their families. This building with its inmates was floated off, but in its progress down the stream it encountered the inshore end of a more substantial dwelling, which gave it a direction towards the wheel house of the factory against which it lodged, in a position opposite to a window of the picker house. From the upper window of his dwelling (which was partly under water) Rigley not only escaped himself to the second story of the picker house, but succeeded in rescuing his wife and child. But his good offices did not end here. Toombs, (who was sick) his wife, and two children were in the garret of their dwelling, shut out from the light, the roof being partly under water. Rigley, after placing his own family in safety, made an effort worthy of all praise, to rescue his fellow sufferers. He returned to the almost submerged building, broke a hole through the roof, and took Toombs and his family and placed them safely in

the picker house. "In half a minute," as he expressed himself, after he had returned to the building the last time, their late dwelling was whirled over the wheel house, dashed to pieces and carried down the stream. Mr. Rigley stated that but six minutes had elapsed from the time the house lodged against the wheel house until it was carried down the creek.

Edward Lewis, Esq., and his son Edward were placed in a situation of great peril. They were in the third story of the grist mill, when the building began to yield to the force of the flood—their paper mill and saw mill having previously been swept away, and a current of great depth and velocity passing between the mill and their dwelling, across which was their only chance of retreat. A great part of the walls of the mill was carried away, and the roof and timbers fell in confusion around them, but fortunately enough of this building remained firm to save them from a watery grave, which at one time appeared, both to themselves and to others who witnessed the awful scene, to be their inevitable fate. They were, at length, however, rescued by the use of a rope.

On *Chester Creek* seven human beings were deprived of their lives by the flood, and many persons were placed in situations of great jeopardy.

Mary Jackson, a colored woman aged 25 years, while assisting her husband to save some wood on the meadow near Flower's mill, from being carried away, was overtaken by the sudden rise of the water and drowned. It appears that her life might have been preserved had it not been for her hesitancy in fleeing to the nearest point of safety. Her body was found shortly afterwards, and while still warm. This woman appears to have been held in high esteem by those who knew her, and she has left a husband and several small children to deplore her untimely end.

Near the same place where Mary Jackson lost her life, the life of Mr. William G. Flower was subjected to the most imminent peril. Mr. Flower was upon the meadow when the flood came down in a wave, (represented by the spectators as

being from three to four feet high) and swept him away. He was carried from his path into an old race where he succeeded in catching a grape vine attached to a tree standing on the race bank, by means of which he succeeded in gaining a position on the tree, which, however, was soon uprooted and borne away. After a short period of extreme peril during which he was several times overwhelmed by trees, timber, &c., borne down with frightful velocity by the flood, he was again lodged in the branches of another tree, larger and less exposed than the one from which he had been carried. When he disappeared under the floating trees and timbers, the by-standers supposed he was inevitably lost, and left the station they had occupied on the shore. He had great difficulty in gaining a position on the second tree, in consequence of exhaustion, but when he succeeded he remained there in comparative ease and safety. He was at length discovered in this situation by persons on the shore, and as soon as the flood had somewhat abated, and the stream ceased to bring down floating timbers, &c., (which made any attempt to reach him extremely perilous,) Mr. Abner Wood, with a courage and benevolence which deserves the highest credit, swam off to him with a rope, by means of which he was safely brought to the shore. This was at half past nine o'clock, when the water had fallen ten feet.

No lives were lost at the town of Chester, but several persons were placed in a situation of great peril in the house occupied by William Kerlin, Jr., adjoining the eastern abutment of the suspension bridge. The narrative of the exposure of these persons, will be given nearly in the words of Caleb Peirce, who communicated the same to the committee, and who happened to be one of the party. It also gives a very good idea of the extreme suddenness in the rise of the water at that place. Mr. Peirce observes, that " Mr. ———, myself and little son were standing on the pavement near my door, when a person passed by, calling out, ' Mr. Pierce, there is a freshet coming down the creek : Flower's bridge is

gone.' We immediately proceeded down to the suspension bridge, and when we arrived there, we found the creek about as usual, but could see a tremendous wave, as it were, come tumbling over and over, a short distance above, and moving with great force and velocity. The bridge and eastern abutment soon became crowded with people, when I took my boy and went into Mr. Kerlin's shop and looked out at the front door. I suppose we remained in the house, looking at the wreck going down the stream, such as bridges, detached parts of factories and mills, cotton bales, casks of various kinds, carriages, hay stacks, &c., about ten minutes, when we came to the back door (in view of the bridge). The people had all retreated, and the water was rushing with great violence between us and the town, to the depth of from four to six feet, so as to make it extremely dangerous, if not impossible, to reach it. Here we had to remain, the water rising with great rapidity until 8 o'clock and 5 minutes, at which time the flood reached its extreme height. For about half an hour preceding the extreme elevation of the flood, we expected every moment to be carried away. The water then fell with as much rapidity as it had risen, and at a quarter past nine o'clock, the water had disappeared between Mr. Kerlin's house and the town. * * * If the eastern abutment of the bridge had given way as the western did, we all would inevitably have been lost, and we should therefore feel very thankful for our safe deliverance from such a perilous situation.'" Besides Mr. Peirce and his son, and Mr. Kerlin and his wife, there were five other persons in the house.

Mr. Jonathan Dutton was placed in a situation of extreme jeopardy. While endeavoring to place some of the property in his mill out of the reach of the flood, he was surprised by the sudden rise of the water to an alarming and unprecedented height. He retreated from story to story of the mill, until he reached the upper one. His situation soon became more awfully perilous, for the mill began to yield to the force of the torrent. Knowing that his situation had now become

desperate, he leaped from a window in the mill, and with great exertion succeeded in reaching the shore, about one hundred yards below. He saw the mill no more. If Mr. Dutton had remained in the mill a moment longer, he inevitably would have perished.

We now come to narrate one of the most tragical scenes which the flood has given rise to. John Rhoads, an Englishman by birth, but for many years a resident of the vicinity of Pennsgrove, a man past the prime of life, with his daughters Hannah and Jane, both respectable young women, together with Mary Ann Collingsworth, the grand daughter of John Rhoads, were swept off in their little dwelling, and all drowned. Mary Ann, the grand-child, was a highly interesting little girl of seven or eight years of age, and had just arrived from Manayunk, the residence of her parents, on a visit to relatives in the vicinity of Rockdale. Her afflicted mother was not only left to mourn the loss of her child, but her two sisters and aged father. Hannah and Jane Rhoads were aged about twenty-five or thirty years. The old gentleman had been advised to seek a place of more safety than his dwelling afforded, but he felt secure and remained until all chance of escape had gone. In giving a detail of the loss of property by the flood at Pennsgrove, it will be remembered that one of the houses belonging to John Rhoads, which was carried off, was in the occupancy of Thomas McGuigan and Mrs. Morton. The only portion of the family at home in this house, at the time of the sudden rise in the water was Mary Jane McGuigan, the wife of Thomas McGuigan, a young married woman with her only child, a babe at the breast. These also perished.

The body of John Rhoads was found two and a half miles below, and that of one of the daughters, at the mouth of Baldwin's run, still two miles lower down the creek. The body of the other daughter was carried down into the Delaware, and was found near the mouth of Naaman's creek, below Marcus Hook. The bodies of Mary Jane McGuigan

and her infant, and that of the little girl from Manayunk, have not yet been found.*

The occupants of the other houses which were carried off, escaped early, some of them by wading the current which swept around their dwellings at imminent hazard, as it rose with fearful rapidity.

In Pennsgrove, a house occupied by Samuel Riddle, standing very near the four tenements of John Rhoads which were carried away, became a resort for several females, as a place of safety. These, with the resident inmates, all females, (Mr. Riddle himself being at the factory,) were, during a long time in a very perilous situation. A survey of the present ruined condition of this house cannot but cause a shudder, with the fact in view, that here were twelve or thirteen young women in an upper story without a chance of escape, while every thing around them had been washed away. Full in their view, house after house had swept by, and amidst the roar of troubled waters, the crash of falling timbers, and the shrieks of the perishing Rhoads family, here they were with no other reasonable expectation but immediate death. Some of these females manifested a firmness and resignation of rare character; and after they had, on bended knees, with their hands clasped in each other's, committed themselves body and soul to Him who controls the winds and "taketh up the waters as a little thing," they waited with true Christian fortitude in momentary expectation of a watery grave.

But the frail building which they occupied was not destined to fall. A large tree bent over to protect an exposed

*The body of the little girl has been found since the manuscript of this report was placed in the hands of the publisher. The heavy rain which occurred on the 17th of January, caused a freshet in the creek which removed a deposit of earth made by the flood of the 5th of August, a short distance from the place where the houses of Mr. Rhoads had stood, and exposed the remains of this child. They were identified by the clothing.

corner, and though itself partially uprooted, served to parry off heavy drift wood, and to divide the current. Another exposed corner was "founded upon a rock." The rock itself was nearly undermined, but yet it moved not, and the present appearance of this ruined dwelling excites surprise, that being so nearly washed down, it should have continued to stand. In beholding it one is forcibly reminded of those passages in the Old Testament, which refer by comparison to the influence of floods in the mountainous regions of that land, the history of which is of so lively interest to a Christian people.

Besides those above enumerated, no other lives were lost on Chester creek, and the committee are not aware that any others were subjected to great hazard.*

DENUDING AND TRANSPORTING POWER OF THE FLOOD.

Mr. De La Beche, in his Geographical Manuel, has the following remarks in relation to a flood occurring in a cultivated country, which are in many respects applicable to the flood under consideration. He observes that "the works of man greatly aid the destructive power of a flood. Instead of a body of water rushing into a plain, where from its diffusion over a more considerable space, its velocity and transporting power are both diminished, all cross hedges and bridges, though they may check the waters for a moment, are the means of producing innumerable debacles, when they give way before the pressure exerted upon them. Suppose a bridge

*Two days after the flood another life was lost in consequence of the change produced in the channel of Rocky run, a short distance below Green's factory. Reuben Yarnall, Jr., the son of Reuben Yarnall, of Edgmont, a youth of about ten years, had been in the practice of bathing at this place, previously to the freshet. He subsequently went into the same place, and was drowned—the flood having produced such an excavation in the bed of the stream as to cause the water to be eight feet deep where it had heretofore measured but eighteen inches.

arrests the progress of a flood downwards, and, as very frequently happens on small plains, a causeway connects the bridge with the hill on either side, the waters will accumulate, and will finally burst through the least resisting part of the barrier, which will most probably be the bridge. Having once found a vent, the pent up waters will issue forth with a velocity proportioned to the difference in the level and mass of water, and a debacle will be produced whose transporting power will be much greater than that of the general force of the flood, if no such barrier existed. It must also be recollected, that man by his contrivance of ditches and drains, prevents the rain water from remaining the time that it would otherwise do on the slopes of hills, conducting it, as he does, by numerous free channels into the vallies below; so that in a given time, a much greater body of water is collected than could happen in an uncultivated country." In addition to this, it may be remarked, that clearing a country of timber will greatly add to the velocity with which a flood will pass along the vallies of the streams.*

Nothing connected with the late freshet has caused more astonishment than the numerous facts which it has given rise to, exhibiting the power of deep and rapid currents in transporting materials of a higher specific gravity than water—that is, materials of a greater weight than water, bulk for bulk. Rocks of great weight, and materials composed chiefly or wholly of iron, were in many instances transported to very considerable distances from the places which they had previously occupied.

In the transportation of rocks and stones in water, it must

* It has been observed since the great freshet, that the creeks rise in a much shorter time after a rain than they did previously. This is particularly the case with Chester creek. The change in this respect is readily accounted for. The channel of every water course, however small, has been so completely swept out, so entirely freed from obstruction, that the water is permitted to pass along to the large creeks in a much shorter time than formerly.

be borne in mind that their weight is greatly diminished by being immersed in that fluid. Very few rocks have a greater specific gravity than 3, and the greater number do not much exceed 2.5. The heaviest varieties of rocks will therefore be deprived of one-third of their weight, and the lighter kinds which are found in this county, will weigh two-fifths less in water than in the air. But in regard to materials composed of iron, the comparative difference in weight will be inconsiderable, as this substance is deprived of less than one-seventh of its weight by immersion in water—its specific gravity being from 7.6 to 7.8.

It has been laid down "that a velocity of water equal to three inches per second, is sufficient to tear up fine clay—six inches per second, fine sand—twelve inches per second, fine gravel—and three feet per second, stones the size of an egg." It is doubtful whether results given as the above, without any reference to the depth of the water, can be of any practical utility; for it certainly does appear that the power of water to transport ponderous substances depends, in some degree, on the depth as well as on the velocity of the current. Numerous facts in support of this position might be referred to as the result of the flood under consideration. Rocks, stones, gravel, &c., are almost uniformly deposited where the current of the flood became more shallow, and in very many instances, apparently in the face of a current equally rapid with that which brought them to the point at which they rested.

In a clear, shallow stream, with a stony bed and a moderate velocity, we see that the water when it comes in contact with each small stone, or other inequality in the bed, rises over it, causing in the surface of the stream somewhat of the unevenness of the bottom, and giving rise to what is usually termed "ripples." Now the same thing will undoubtedly take place to some extent, when the water is much deeper, and the obstructions much larger. But will not the power of the water to rise over an obstruction be diminished, in a

measure, as the stream increases in depth, supposing the velocity to remain the same? If that be true, it must be perfectly apparent, that a point will be reached where the difficulty experienced by the deep water in passing over the obstruction will be so great that the obstruction itself must yield its position, and be carried down the current.

In passing over the same descent, the increase in velocity which a stream acquires as it becomes deeper, is, no doubt, very considerable, and full allowance for this should be made in explanation of the fact, that these heavy materials are usually deposited at points where the water is diminished in depth; but it should also be borne in mind, that this increase of velocity is much greater at the surface than any near the bottom of the stream — the velocity always being the least at the bottom.

The friction of the water over these ponderous obstructions is another ingredient which must be taken into account in explaining their transportation. Loaded as the water is with heavy sediment, during the time of a great flood, with its depth and velocity greatly increased, its friction on the bed of the stream, or upon obstructions resting on the bed, must be very considerable. In fact it is only necessary for the friction of the water in passing over an obstacle, to exceed the friction the body in moving would have on the bed of the stream, to insure its transportation from this cause alone. It will be difficult to explain the removal of certain thin, flat stones of considerable dimensions, which actually took place, without taking this item of force largely into the account.

To enter into a full detail of all the facts under this head, which came to the knowledge of the committee, would be tedious and uninteresting, and could answer no valuable purpose. In the details of the flood which have already been given, sufficient evidence was exhibited of its tremendous force, in the sweeping away of mill dams and bridges, of mills and dwellings, and in the uprooting of many trees, and the dis severance of the massive trunks of others. The com-

paratively few facts which will be added, will be such as have a geological bearing, or which more appropriately belong under the head of this section.

Many places along all the creeks exhibit the denuding power of the flood, which swept along their vallies in a striking manner. Very many meadows are greatly damaged by having the soil removed in some places, and large deposits of stones, gravel and sand made in others. The sites of many gardens, or beautiful plots of grass, now exhibit nothing but the naked rock, or lie buried beneath a mass of detritus, several feet in depth. The beds of the streams are in many places deepened, and in others wholly or partially filled up.

On Ithen creek, near J. Evans' mill, a trap rock, more than seven feet long and two feet square, was removed many yards from the place where it had before laid. Near this place the channel of the creek was deepened six feet, and a short distance below its bed, was nearly filled with large and small stones.

On Darby creek the denuding power of the flood was exhibited in a very extraordinary manner, on the estate of Thomas Garrett, deceased. The surface from a considerable portion of the valley of the creek was carried away, and in many places to a great depth. It will be remembered that an unoccupied house was carried from these premises. Not only every vestige of the house was removed, but the earth has been excavated to a considerable depth below its foundations. At Lobb's cotton factory, occupied by D. & C. Kelly, several iron shafts, were carried a distance of one hundred feet, and lodged in the tail race of the mill. One of these shafts was ten feet long and six inches square and was partly buried in the earth. There was, however, a small iron wheel attached to one end of this large shaft, which no doubt aided in its transportation. A short distance below, a rock estimated to weigh about two and a half tons, was carried from the bed of the creek, and now lies two hundred yards below, on an adjoining flat.

On Crum creek, at T. C. Palmer's mills, the excavating power of the flood was very strikingly exhibited. A portion of his dam was swept out, and below the breach an excavation was made to the depth of twelve feet. Part of the excavation occupies the former site of his wagon house, which was undermined and carried away. At Beatty's mills, and at Lewis' mills, the denuding and transporting power of the flood were strongly marked, in the excavations which it caused, and in the removal of heavy materials.

A breach of twenty or thirty feet in extent was made by the ice freshet of 1839, in the stone breast of the dam of Enos Sharpless, on Ridley creek. This breach had been rebuilt with large stones, weighing from ten to twenty hundred weight, and in order to make it more secure, these stones were fastened together with straps of iron from one half inch to one inch square, being bolted to the stones, and thus two, three or more of these large stones were connected together all through the wall. This part of the wall was all torn out by the flood, and no two of these large stones were found fastened together, but in nearly all cases the bars of iron were broken off—in a few cases in which the bolts were drawn out, the bars have been twisted and bent as if they had been no more than bars of lead. Three of these stones having been thus fastened together on the wing-wall of the dam, were carried sixty or eighty yards down the creek, where two of them but little short of two tons weight each, lodged against trees, with the irons broken off. On a meadow of Mr. S. a quarter of an acre was divested of its surface, and an acre covered with stones, gravel and sand. A meadow of about five acres, belonging to Jonathan Thomas, was excavated to the depth of four or five feet in some parts, and in other parts covered with a deposit of stones, gravel, &c., to the depth of three feet. Great changes have been produced in many places along the valley of this stream, many of the rich flats have been rendered nearly valueless by deep excavations or heavy deposits of stony materials. In the vicinity of the factories

of C. Sherman and that of S. Bancroft, and of the mills of Edward Lewis and Amor Bishop, it will require ages to obliterate the traces which have been left by the flood.

Many trees, some of them of a large size, were uprooted, or had their trunks dis severed upon this stream, and were carried down.

But the most indelible marks of the flood will be found in the valley of Chester creek. In fact the changes produced upon this stream are so similar in character, that it would be useless to enter into a general enumeration of them. What occurred at a few places will serve to illustrate the power and force of the flood in this stream, throughout nearly its whole length. Even as high up as the residence of the Hon. Henry Myers, in Concord, "every streamlet and ravine passed torrents of water, carrying with it earth, gravel, stones, and rocks, and depositing them on the fields and meadows, so that even here the marks of this flood will remain for many years to come.

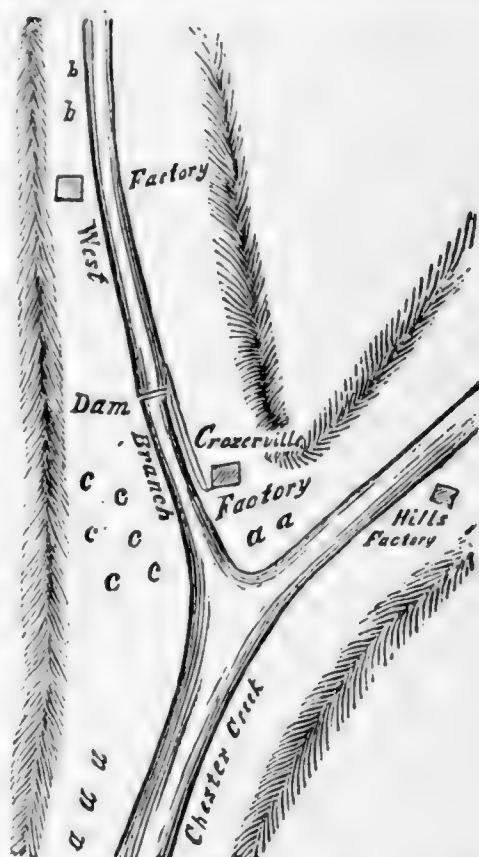
Along Green's creek, a more southerly branch, large trees were uprooted and carried down, and the surface in many places excavated in such a manner as to make it very apparent, that the district of country drained by this small stream was subjected to rather an undue share of the heavy rain. Below where this stream enters the main West branch, the changes continue in an increased degree. On this stream above its junction with the East branch, the power of the current was remarkable, and scarcely within the belief of persons who have not witnessed the like. Mr. Crozer's West branch dam was built of stone of a large size. Nearly all of them were such as would require a yoke of good oxen to haul with timber wheels on level ground. These were carried down the stream from one to four hundred yards, and along the bed and margin of the natural channel, rocks of many tons weight were removed from beds in which they had probably laid for ages—upturned, and in some instances, carried down a number of yards.

A flat between the West branch dam breast and the factory, has a deposit of coarse sand and gravel, averaging nearly two feet in depth, and covering more than half an acre. Another flat opposite Crozerville factory, is covered with rocks, stones, and gravel, to the extent of more than two acres, and the creek at the same place, which flowed heretofore in a bed flanked by banks of from four to six feet high, has entirely changed its channel—the old bed being filled up with stones and coarse gravel, so as to form a surface level with the former banks. On the opposite side, and in the forks of the creek, as has been before mentioned, a deposit of mud four or five inches deep, covers a lot of three-fourths of an acre, while large beds of sand are piled up in various places. The annexed cut (next page) will serve to illustrate the relative situation of these deposits. The cause of the deposits of mud being made at this point, is sufficiently explained in another part of the report. The largest rock noticed, the resting place of which had unquestionably been changed by the flood, was one near Crozerville dam. This rock is estimated to weigh from ten to twelve tons, and was removed a distance of four or five rods. Its former position was well known, but what confirms the fact of its removal beyond a single doubt, it was found resting against and upon another rock with a piece of domestic goods between the two.

Below the junction of the two streams in the vicinity of Pennsgrove and Rockdale, the changes produced are very striking. The valley of the creek, in many places to a considerable width is entirely divested of its surface, while in other parts it is strewn with gravel, stones and rocks, many of them of an enormous size. What is most strange, persons residing in the neighborhood, are at a loss to tell where all these rocks and stones were brought from. Many materials from this vicinity, composed wholly or nearly altogether of iron, were in many instances carried to great distances. An iron boiler weighing over seventeen hundred weight, was carried from Mr. Crozer's West branch factory, and lodged in

Riddle's dam at Pennsgrove, a distance of about a mile, and when found it contained several hundred weight of sand and gravel. Power looms, either entire or in parts, were carried many miles, together with portions of other machinery, chiefly composed of iron. An iron pot supposed to weigh from five to six hundred pounds, and of a hemispherical shape (a form unfavorable to its transportation) was carried from some of the factories above, and lodged on the farm of Samuel West.*

Beaver creek, though a small stream, was very turbulent, and rushed into the Brandywine with so much force as to dam that stream more than a mile above their junction, and causing heavy deposits of mud, gravel, &c., along its valley. Immediately below the mouth of the



creek, on the meadow of Elihu Talley, this deposit is four feet deep in some places, and covers about two acres. On this small stream, near Smith's mill, a rock nine feet long, seven feet wide, and three and a half feet thick was removed ten feet from its former position.

The deposit of mud that was made at the junction of the two main branches of Chester creek, sufficiently attests how

*EXPLANATION OF THE CUT.—*a. a.* deposit of mud.
b. b. deposit of gravel and sand.
c. c. c. c. deposit of rocks, stones and gravel.
d. d. d. deposit of sand.

heavily the waters of the flood were charged with earthy particles. The amount of mud which was carried down and deposited in the Delaware, must have been incalculably great.

The destruction of property did not end with that which was caused by the wind and flood. The large stone barn of Lewis Davis, in Haverford, was struck by lightning about five o'clock in the afternoon, and after the most persevering efforts to extinguish the fire which had been communicated to the hay contained in the building, continued by the people of the neighborhood, for the space of three hours, the barn together with about fifty tons of hay and a quantity of wheat and oats, was consumed. The loss of Mr. Davis cannot be less than two thousand dollars, and that of another person who had his property in the barn, about one hundred dollars. The electric fluid with which the clouds appeared to be so highly charged, took effect in several other places in the county, but did not cause any serious damage, so far as the committee are informed.

On the night of the flood, the air was bland, with a light breeze from the S. E. The moon occasionally shed its rays through the floating clouds, while the light caused by the burning of Mr. Davis' barn, was visible all over the county, and constituted a brilliant though awful *finale* to an event which in all time to come must mark an epoch in the history of the county of no ordinary importance.

For the accompanying Map of Delaware county, the committee are indebted to William H. Wilson, Esq., of Haverford. It was drawn expressly to illustrate the subject of this report, and was not intended as a map of the county to be used for general purposes. In the construction of it, much has therefore been purposely omitted which would be useful in such a map. In fact, the greater part of this map was reduced from a large, unfinished, manuscript map of the county, drawn many years ago, by Mr. John Hill. This old

map, so far as it was completed, is known to contain many inaccuracies. A few of these have been corrected, but no doubt several of them have been introduced into the new map. In laying down those parts of the county which are incomplete in the old map, the data upon which Mr. Wilson had to rely, was necessarily of such an imperfect character, that little doubt exists, but several errors have found a place from this cause. The map, however, is handsomely executed, and will serve the purpose for which it was intended, equally well with one that had been made out from an accurate survey of the county.

(The Institute regrets that owing to the condition of the map above referred to, it has been found impossible to reproduce it for this reprint.)

ERRATUM.—On page 10, seventeenth line from bottom, “resembling a water spout,” should read “like the bursting of a water spout.”

On page 37, fifteenth line from bottom, “must” should read “next.”

CHARLES POTTS.

The death of Charles Potts, Vice President of the Institute, being announced, the following minute was adopted and the Secretary instructed to record the same : —

In the death of Charles Potts the Institute loses from its membership a man of rare culture and character. He became a member on March 1, 1889, and was active and interested in the affairs of the Institute until his last illness. He was pre-eminently a teacher in the best sense of the word. His long career at Westtown School left its mark on hundreds of students, and after he retired from professional life he still retained active interest in the education and training of the younger generation. He not only gave instruction, but he gave that personal teaching which trains character.

During all his life he was a keen observer of nature. His scope of study and thought covered what the passing generation of scientists called Natural History, and the accuracy of his knowledge often surprised the younger scientists even in their special studies. His influence and teaching were not obtained by literary productions, but rather through his personal talks. His skill in the use of the English language rendered his contributions and discussions at the Institute always interesting to those who heard him. He had the rare combination of the ability to study and understand, and also the art to describe and impress it upon others.

The Institute not only regrets its own loss in the death of Charles Potts, but extends its sympathy to his relatives and friends upon the removal from their midst of a man whose character and intellectual qualities always worked toward truth and good life.

MINUTES OF THE INSTITUTE.

NOVEMBER 3, 1910.—Regular monthly meeting, with Vice President Henry L. Broomall in the chair. Reports of committees and Curators and routine business. The following additions to the library were reported: "Pennsylvania Archives," presented by H. J. Makiver; "Comstock's Manual for the Study of Insects." A committee was appointed to secure an improved means of illumination for microscopical purposes, and to consider a better illumination of the hall of the Institute. Albert S. Barker and C. Edgar Ogden were appointed to attend the meeting of the Delaware Valley Naturalists' Union, to be held November 4th, and to make report from the Institute. Under scientific communications C. M. Broomall reported upon progress made in bacterial culture from samples of Media water, and Albert S. Barker showed spore cases of moss under the microscope and explained the structure of the hairy cap and stalk. Adjourned.

NOVEMBER 10, 1910.—Adjourned meeting. Lecture, "A Glimpse beyond the Continental Divide," by Dr. Trimble Pratt.

DECEMBER 1, 1910.—Regular monthly meeting, with Vice President Henry L. Broomall in the chair. Reports of committees and officers and routine business. The following additions to the library were announced: "Pressure of Light," by J. H. Poynting; "Proceedings of the United States National Museum, Volume 37;" "Contributions from the U. S. National Herbarium, Volume 13, Part 6, and Volume 15;" "Report of the U. S. National Museum on some West Indian Echinoids, Bulletin 74;" "An Account of the Beaked Whales of the Family *Ziphiidae* in the Collection of the U. S. National Museum, with remarks on some specimens in other American museums,—Bulletin 74, Report of U. S. National Museum;" "Geological Atlas of the United States, U. S.

Geological Survey." Chairman Henry L. Broomall, of the committee to draft a resolution on the death of Charles Potts, which occurred October 5th, read the minute which appears on page 87 of this issue of the PROCEEDINGS. After the regular order of business had been disposed of, Benjamin Levis, of Media, exhibited some relics which he had gathered in the vicinity of Crum creek, near Palmer's mill. The specimens consisted of arrow heads, tomahawks and various stone implements. Mr. Levis stated that this vicinity seemed to be quite rich in these relics, indicating that at one time it might have been the site of an Indian village. A suggestion that a party from the Institute explore the grounds was received with favor. On motion a vote of thanks was extended to Mr. Levis for his contribution and interesting presentation of his subject. A report being called for from the party consisting of C. M. Broomall, Albert S. Barker, Señor Castener, Sanford Omensetter and B. M. Underhill, which recently went on a tour of exploration of Mineral Hill, it was stated that all members of the party had fully recovered, and the report was received with expressions of pleasure. Henry L. Broomall, being asked to say a few words upon the North American Indians, gave some interesting facts as to their written records. He stated that no truly written records of these people had yet been found—that such record as had been found was pictorial. Mr. Broomall stated that south of the Rio Grande writings had been found which were not pictorial, and that these inscriptions were somewhat more advanced than the Egyptian hieroglyphics, which were pictorial. The Mexican inscriptions were pictorial in origin, but that idea had been lost, and evidently they had come to be used as phonetic letters. Mr. Broomall stated that the Indians had no alphabet and, in fact, no use for one until very late in the history of the race. Meeting adjourned.

DECEMBER 8, 1910. — Adjourned meeting. Lecture,

"Summer Botanizing in the Mountains of New York and New Hampshire," illustrated with specimens, by George B. Kaiser.

DECEMBER 22, 1910.—Adjourned meeting. Illustrated lecture, "St. Petersburg and Moscow," by S. L. Schumo. The main subject was followed by illustrations of water erosion, commonly known as "pot holes."

JANUARY 5, 1911.—Regular monthly meeting, with Vice President Henry L. Broomall in the chair. Reports of officers and routine business. C. E. Ogden exhibited Belemites from the Cretaceous formation of Mullica Hill, New Jersey. Albert S. Barker showed a spectroscope with bisulphide of carbon prism, giving wide dispersion of color and continuous spectrum, absorption bands and line spectra. Adjourned.

JANUARY 12, 1911.—Adjourned meeting. Lecture, "Molecular Masses of Liquids," illustrated by charts, by Dr. George H. Meeker.

MINUTES OF SECTION A.

NOVEMBER 17, 1910.—C. M. Broomall exhibited cultures of bacteria from Ridley creek, Broomall's dam and the Asylum run, together with the comparative generation of gas in fermentation tubes in samples from the above localities. Also a specimen of "peacock coal" found in the Institute supply. Albert S. Barker drew attention to the cup shaped termination to the pedicle which on the leaves of the poplar enclosed the bud for the succeeding Spring. He also with crystallized calcite showed double refraction and on the blackboard gave a clear exposition of the polarization of light.

DECEMBER 15, 1910.—T. Chalkley Palmer spoke on methods of staining *Surirella*, and C. Edgar Ogden on geological characteristics of eastern Pennsylvania and New Jersey.

DECEMBER 29, 1910.—C. M. Broomall illustrated and spoke upon his experiments with bacterial culture, and explained the method of the separation of silica and clay by means of green soap. C. Edgar Ogden showed under the microscope a fine collection of diatoms and desmids. Henry L. Broomall spoke on "The Verb."

JANUARY 19, 1911.—C. M. Broomall made some remarks upon an article on the pressure of wind on weather vanes, in which it was claimed the pressure was greater when the wind struck the vane at an angle. He also explained the theory of the fountain ball. Henry L. Broomall spoke on the Ainos of Japan, and illustrated the difference between an inflected and an agglutinative language.

JANUARY 26, 1911.—In relation the preservation of microscopical slides, John W. Palmer exhibited a specimen of *Volvox* which had remained in good condition for fifteen years.

INSTITUTE NOTES.

This number of the PROCEEDINGS somewhat appropriately makes its issue on the sixty-eighth anniversary of the Flood of 1843. In printing the article some effort has been made to preserve the quaintness of spelling and construction which obtains in the original. This is our warrant for what otherwise might be classed as errors in composition.

Among the historical curios contained in the museum of the Institute is a small block of soapstone on which is cut the date 1770. Nothing is known of its history, and there appears no record of it on the minutes. Any information concerning this specimen will be appreciated.

During recent months a systematic series of bacteriological examinations of the Media water supply has been made in the laboratory of the Institute. The results indicate the water to be of first class quality.

The mounted specimens shown by Dr. Krout and Mr. Kaiser, in their recent lectures, excited much favorable comment by reason of their neatness of mounting as well as for their great scientific value.

The current Winter has been noteworthy for the early commencement of cold weather. Early in December the excessively low temperatures began, and were continued for quite an extended period.

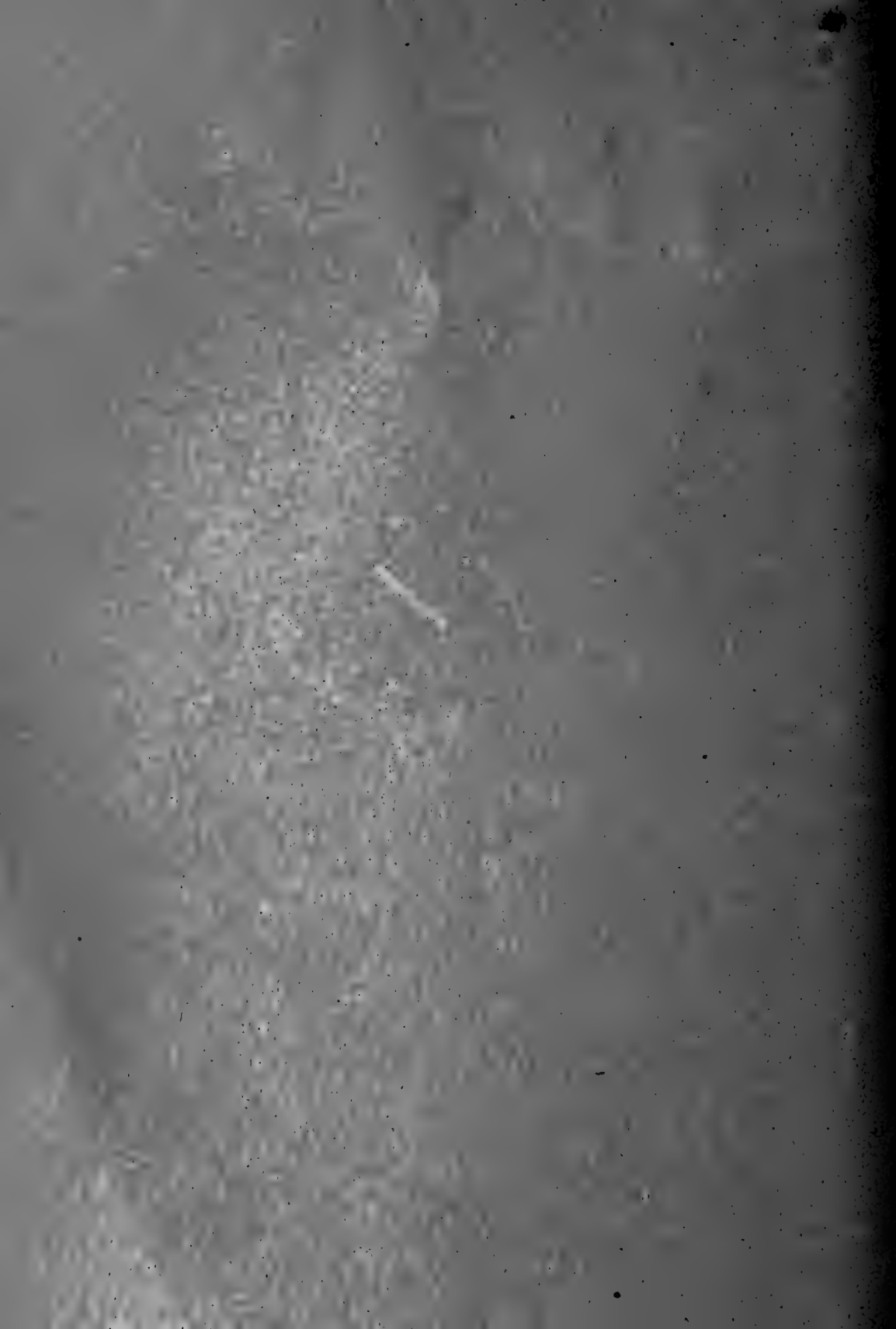
The cuts in this issue of the PROCEEDINGS were reproduced from photographs taken from the printed pages of the original report by Albert W. Barker.

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April, 1911

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OF THE
DELAWARE COUNTY
INSTITUTE OF SCIENCE

PUBLICATION COMMITTEE:

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. VI, No. 3

APRIL, 1911

PARASITIC ADAPTATION.

BY B. M. UNDERHILL, V. M. D.

Living things upon cursory observation appear to be at peace with one another, and little may be noticed that is disturbing to the harmony between the organism and its environment. We find, however, on more careful examination, that there are sources of constant interference operating to destroy organisms, to restrict their multiplication, or even bring about their total extinction. Animals prey one upon another, and drive each other from a favorable to an unfavorable habitat, while changes in the earth's surface and in climatic conditions make localities inhospitable to certain animal groups which previously had thrived amid favorable surroundings. There is, in fact, a perpetual "struggle for existence" which may lead to the seeking of shelter from the conflict in a changed and often degenerate mode of life to which the animal becomes adaptively modified. Thus, through such influences, we may have a terrestrial animal driven to an arboreal or even an aquatic or semi-aquatic existence. A defenseless little member of the Insectivora burrows and becomes subterranean, while another finds protection in the nocturnal habit, others seek the shelter of caves or rock crevices, and we often find creatures, usually somewhat degenerate, in places which seem to us quite unfavorable to the support of even the higher invertebrates. While in such cases

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BOTANICAL
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the animal continues to lead a free and independent, often solitary existence, a communion of life's interests may be established between two animal organisms which causes us to surmise that this association is founded upon some mutual advantage in the strife. To such association the general term symbiosis has been applied, and each of the organisms concerned is referred to as a symbiont. Though there is by no means a uniformity in the use of these terms by zoologists, it will serve here to subdivide symbiosis into the three categories, mutualism, commensalism and parasitism. In the first there is a reciprocal advantage derived from the union; in the second but one symbiont is benefitted though the other suffers no harm, while in the third division we have one receiving an advantage to the detriment of the animal which it invades. There is, however, no sharp line of demarcation between these three states of living together, and it may be difficult to determine in some cases whether one or both symbionts are benefitted by the union, or whether one is or is not injured by it.

One of the more obvious examples of mutualism is the case of the hermit crab and the sea anemone. This crab selects a shell, often that of the whelk, for its habitation, from the opening of which it projects only its head and claws. On the surface of the shell may often be found a sea anemone fastened near the opening, with its mouth and tentacles in the vicinity of the crab's head. The anemone in this position not only in a measure serves to conceal the hermit crab from its enemies, but the creature that would prey upon the crab must first reckon with the dangerous, stinging threads with which the tentacles of the anemone are armed. The anemone is benefitted, in its turn, by being carried about by the crab and aided in this way in obtaining its food.

Such associations, however, are not always of mutual advantage, and may be more in the nature of an invasion of one animal upon or within the body of another, the invading animal alone deriving benefit, while the animal upon which

the association is forced, though not benefitting, may in no way suffer from it. A familiar form of this living together (commensalism) is the little crab so commonly found in the shell of the oyster. The oyster is not harmed by its presence, but the crab is benefitted by the protection which the shell affords. Another more curious example of such association is afforded among the vertebrates by the species of *Remora*, or suck fishes, which have the first dorsal fin modified into a sucking disc on top of the head. By means of this disc it attaches itself to a shark or other large fish, and is thus carried about, detaching itself only to secure food. Its benefit from such association is in being carried to new feeding grounds without effort of its own, and in the shelter from its enemies which the body of the larger fish may afford. The host, on the other hand, cannot be benefitted, nor does it seem to suffer by the presence of its uninvited guest.

Whether this relationship between different species is of reciprocal advantage, or of benefit to but one, neither of the symbionts lives upon or at the expense of its co-symbiont, and neither has entirely renounced its independence. In true parasitism the invading animal lives at the expense of its host. We have many familiar examples of this form of symbiosis, and the conditions that seem always to attend it, such as the degeneration, slight or extreme, of the parasite, are familiar to all observers of animal life. It is the common habit of many animals, however, to prey upon the bodies of other animals, and we should distinguish, so far as we may, between those which are predatory in habit and those which are parasitic. The former are free, and exercise their powers of sense and cunning in snaring or chasing their prey, while the latter live on or in the bodies of their victims, often burrowing into and consuming the body substance, leading a lazy, beggarly existence in which all the faculties of special sense and prowess, so highly developed in predatory animals, become degenerate through the atrophy of disuse.

Parasitism is found throughout the range of animal life

from the unicellular to the vertebrate, and, though we may not make a sharp distinction between predaceous and parasitic animals, in view of the degrading influence of the parasitic habit we should clearly define the difference between the simplicity of degeneration and the simplicity of primitiveness. In the development of a primitively simple animal the young stages are more simple than in the adult, and it has had only simple ancestors. In the degenerate animal, on the other hand, the ancestors are often more complex, and the young stages of a higher grade than the stage of the adult, and the adoption of any mode of life which withdraws from the activities and shirks in the pursuit of food seems to bring about this condition of degradation. Of this we have a remarkable example outside of the realm of parasitism in the Tunicata. These aberrant animals in the stage of the free-swimming larva have a chordal axis which in nearly all of the different species becomes entirely lost before they reach maturity. After passing the "tadpole" stage there follows an extreme specialization to the fixed habit which most tunicates retain throughout their adult life, becoming what are known as "sea squirts," mere, attached, plant-like sacks, emitting a jet of water when disturbed, and from which all chordate features have been entirely lost. The degenerative changes which a parasite undergoes concern mostly the nervous system, the organs of locomotion, and those of nutrition, the nervous system becoming reduced to the most indispensable portion, while of the sense-organs nothing may be left except those of touch. The locomotor apparatus may become modified into claws or hooks for clasping the hairs of the host, or may more or less completely disappear and be replaced by such organs of fixation as sucking-disks. As the contents of the alimentary canal or tissue fluids of the host upon which the parasite is nourished need scarcely any digestion, the digestive organs become simplified or may be quite lost, and the absorption of nutriment take place entirely through the body integument, as in the case of some of the worms which

infest the intestines of man and other animals. The degree of decadence will depend upon the degree of dependence upon the host. In this latter respect the parasitism may be optional, as in the case of the mosquito, which may live upon the juices of plants, but which prefers a meal of warm blood, or it may be obligate, depending upon the body of another for its means of subsistence, though such obligate parasites as the biting flies, fleas, and certain household bugs, may also live free and only occasionally visit their hosts, this form being accompanied by little modification. In the event of the parasite becoming progressively degraded into one which not only seeks its host for food, but has become dependent upon it for both its nutrition and place of abode, all of the above mentioned phenomena of adaptation become more conspicuous. We are furnished an interesting example of such a transformation in the so-called sheep tick (*Melophagus ovinus*), not a true tick, however, but a fly, which from an occasional visitor has, like the louse, taken permanent abode upon its host. No longer taking the aerial flight of its discarded free life, this fly has become wingless, and, furthermore, is enabled to pass its entire life cycle upon the body of the host animal by a remarkable method of reproduction involving the retention of the eggs in the oviducts until development has passed through the larval stage. It is not until ready to pass into the stage of the pupa that these are extruded, when the pupal case is attached to the individual wool fibres. From this case the young insect, on becoming sufficiently developed, makes its escape and proceeds to feed and grow, thus rounding out a complete parasitic cycle.

While the easy life of the parasite tends to degeneration, the perpetuation of the species becomes more precarious, and the organs of reproduction undergo a strong development. If a host animal dies, most of its parasites, especially those existing in the interior of its body, die with it and, were it not that the eggs find lodgment in a new host, the parasitic species would in a short time become extinct. The transmis-

sion of but few of these eggs is successfully accomplished, and in compensation they must be produced in enormous numbers, well protected from the many elements of destruction which they encounter. The mode of reproduction is one of the principal factors determining the conditions of parasitism, and, while the above modifications pertain more to those dwelling permanently within the bodies of their hosts, we have in the *Æstridæ*, among the dipterous insects, a cycle involving internal parasitism during the larval stage; a familiar example being the common horse bot fly (*Gastrophilus equi*). In the warmest hours of the day, during the late summer months, the female of this fly hovers about the head, shoulders and fore legs of the horse, then darts down, deposits its egg upon a hair, and at once flies away, soon to return and repeat the process, until hundreds of eggs may be found on the same horse. In about fourteen to twenty days these eggs are hatched, a vivacious larva emerging, which, crawling on the skin, causes a slight irritation, impelling the horse to lick, the larva reaching the mouth in this way, or possibly still within the egg. Being carried to the stomach with the food, it becomes fixed upon the mucous membrane by means of two buccal hooks, and, with head plunged deep into an alveolus, subsists upon the inflammatory products of the small wound which it makes. After a sojourn here of about ten months, the larva becomes detached and is passed along with the intestinal contents, to be finally expelled from the body of its host. It then becomes concealed in the ground; and is soon enclosed in its pupal case, from which, after the elapse of about thirty to forty days, it emerges as the perfect insect. It is plain that a very small percentage of the eggs deposited can reach the horse's mouth, and that having got thus far, many of the larvæ must be destroyed or pass entirely through the intestinal tube without having succeeded in becoming fixed to the mucous lining. For this nature seems to have compensated in the large number of eggs deposited by the persistent female.

While in some cases the complete life cycle of a parasite requires but one host, more often, for reasons above stated, two successive and generally specifically different hosts are required. A rather complicated example of the latter phenomenon is the life history of the common liver fluke (*Fasciola hepatica*), one of the flat worms infesting in its adult state the livers of herbivora. This parasite is interesting in that it must necessarily alternate between a mammal, usually the sheep, and an aquatic snail, in completing its cycle. The adult form occurring in the sheep's liver is leaf-like, about three-quarters of an inch long, and has two prominent suckers, one on the under side of the body and one surrounding the mouth. The eggs, of which each individual fluke is capable of producing in the neighborhood of 100,000, pass into the bile duct of the sheep, from which they enter the alimentary canal and reach the exterior with the excrement. Here, if the proper conditions of moisture and temperature necessary for further development are present, the embryo makes its escape. At this stage it is active, ciliated, free-swimming, and not unlike certain infusoria—the period of the miracidium and a very critical one in its history. It cannot survive in this condition for more than twelve to eighteen hours, therefore if during this time it does not come in contact with a snail it is doomed to perish. Finding its molluscan host (*Limnæa humulis*) the larva, by means of its conical rostrum and a rotary motion of its body, forces its way into the tissue, most frequently that surrounding the lungs. Here it becomes more oval in shape, the cilia disappear, and it enters the stage of the sporocyst, which very early may by simple division produce two individuals. Within the body of the sporocyst there appear from five to eight cellular masses which, becoming transformed into energetically moving bodies, finally rupture the maternal sac and issue forth as so many radiæ—these, on obtaining their liberty, passing through the tissues of the snail and becoming fixed in another organ, usually the liver. Within the body of the redia there are formed daugh-

ter rediæ, which again produce other rediæ, until a large number of these forms become lodged in the tissues of the snail. Finally the redia gives rise to still another form, the cercariæ, which is somewhat heart-shaped and possesses a long and flexible tail. The cercaria leaves the snail host and proceeds to swim energetically about, eventually fixing itself upon an aquatic plant, blade of grass, or other object within or near the water. The tail now disappears, while from certain cells expelled from the body there is formed a cyst in which the cercaria becomes enclosed, the cyst being attached to the blade of grass or other object upon which the cercaria has lodged. If now a herbivorous animal, in grazing over the wet land or in drinking the water in which it may float, swallows this cyst, the cyst wall is broken down in the stomach by the action of the gastric juices, the young fluke is set free, and, reaching the duodenum, finds its way to the liver by way of the bile duct. Here it fixes itself and grows to maturity and the egg-laying stage from which we started upon this peculiar cycle.

It will be noted that this life history is a very hazardous one, and that its completion must depend upon the co-operation of numerous favorable conditions; the eggs must reach the exterior amid surroundings favorable to their hatching. If hatched, the larva must escape its many aquatic enemies, and within a few hours find its suitable snail host. Providing the snail is not eaten by a duck, or does not otherwise perish during this phase of the cycle, it issues from its host as the free-swimming cercaria, when it is again liable to fall prey to various small aquatic animals. Escaping this and becoming encysted, the chance of any herbivorous animal coming along and swallowing it is very small. The relation of the enormous number of eggs and the number of individuals which one egg may produce, to the survival of the species amid conditions fraught with such dangers, seems quite evident.

So varied are the conditions that surround the propagation

of parasites that few of them, of course, can be reviewed here. In general it may be said that their prodigious fecundity and the great vital resistance with which most of them are endowed, enables species to survive and perpetuate their kind amid varied destroying influences which otherwise would bring about their extermination. The *Tænia* inhabiting the intestines of man affords us another example of extreme parasitism accompanied by this remarkable development of the reproductive function. Here is a creature so altered to its degenerate existence that it has become devoid of mouth or intestine, the body consisting of a head from which are given off segments which remain united until there is formed a band-shaped colony of from 1200 to 1300, streaming back from its attachment for a length of from fifteen to twenty feet or more. After about the six hundredth, each segment is a mature and complete sexual individual, which later, as it is pushed on by new segments formed at the head, becomes filled with fecundated eggs. By the successive detachment of these "ripe" segments (proglottids) and their passage from the body of the host, it has been estimated that the unarmed *Tænia* of man (*Tænia saginata*) might throw off in a year as many as 150,000,000 of eggs. These may escape from the uterus of the proglottid, or one to several attached proglottids containing the eggs may become scattered upon the ground. In either case, through their contamination of fodder or drinking water, they may, if so fortunate, reach the stomach of cattle where the egg shells are digested away and the contained embryos set free. At this stage (proscotex) the embryo possesses six minute hooks, arranged in three pairs, by which it bores its way through the intestinal wall and wanders to a muscle, where it comes to rest; or, if it finds its way into a blood vessel, it may be carried with the blood to any organ of the body. Finding its place of lodgment, it loses its hooks, increases in size, and the head of the future tapeworm is then developed in an invagination of the cyst wall with which the embryo has become surrounded. During

this development the cyst pushes the tissues aside to make room for itself, and, through the irritation produced, an outer cyst wall is formed, made up of the connective tissue of the host, the complete organism or bladder worm (*Cysticercus bovis*) thus formed having consumed a period of time from the release of the embryo variously estimated at from seven to eighteen weeks. If the host animal is slaughtered before the *Cysticercus* becomes calcified, which stage of degeneration will be reached in about six to eight months from the invasion, and the incompletely cooked meat be used by man for food, the cyst, upon arriving in the stomach, is digested away, the head and neck (scolex) alone remaining uninjured. The scolex then passing into the small intestine, fastens to the wall by means of the suckers with which its head is provided, obtains nourishment by absorption of nutrient intestinal fluids of its host through the general surface of its body, and proceeds to give rise to segments by transverse division directly back of the head and neck ; thus developing the strobila, or colony of sexually mature proglottids, similar to that of the ancestor from which the cycle started in the intestines of a previous human host. Here then is an animal well showing the degree of degeneration which may be reached in extreme parasitism ; there are no organs of locomotion, no organs of special sense, no organs of digestion, no organs of respiration, and none of circulation. The body consists of a long band of connected segments, each bisexually complete, and in itself a sort of independent reproductive animal, the entire energy of the organism concentrated upon the function of reproduction, that the perpetuation of the species may be insured amid the perils with which this process is beset.

In many forms permanently parasitic there is an early period of development in which organs of locomotion are distinctly present, but, as the animal matures, these fail to develop or become lost. If we assume that this gradual loss of organs, change of structure, and protective transmission of the embryo to an intermediate host is due to the parasitic

life, it seems reasonable to conclude that all of the parasitic groups have been derived from free-living forms, and that, as parasitism became a more fixed habit, such structural changes were in the course of time brought about as would make this mode of life obligatory. Furthermore, by comparison of the different parasitic groups, we find all gradations, from scarcely modified forms which are optional or occasional visitors to their hosts, to those of intense parasitic habit, which show the greatest change of structure and most complicated life history.

MUNICIPAL WATER SUPPLIES.

BY C. M. BROOMALL.

The health of a community varies in more or less direct ratio with the purity of its water supply. The obtaining of such a pure supply and its subsequent preservation from pollution is, therefore, of extreme importance. The matter of such examination of the proposed water supply and its preservation against contamination, is usually placed in the hands of a municipal committee of non-technical men, none of them overly competent to pass upon the chemical and biological questions to be decided. This committee may have before it the reports of engineers, chemists and bacteriologists and yet unfortunately its members may not fully understand the purport of the various technical terms used. The writer has had some little experience in this direction and has more than once seen his reports fall upon unreceptive ears. This and other considerations indicate the necessity that the layman, as well as the expert, should have a knowledge of such subjects. It is hoped, therefore, that what follows may be of interest and aid to the non-technical reader. No attempt is made at originality, and the only object is to give a summary of the minimum of knowledge of principles and laboratory practice necessary for the intelligent operation of a municipal water supply.

Naturally the examination of a given water hinges largely upon laboratory work, and the number of laboratory tests that might be applied to the water is very large. It is, therefore, necessary from this host of tests to sort out those which are best and then to choose from these the least number consistent with the necessities of the case. In describing the laboratory work, no attempt is made to give the full *technique* of the operations, as this is amply treated of in the laboratory manuals.

The consideration and examination of a water supply may be taken up under three heads: First, the watershed;

second, the chemical examination, and third, the bacteriological examination. Let us consider them one by one.

The Watershed. — In the examination of the probability of a given watershed furnishing a proper supply of water, good, common sense is perhaps of more avail than scientific knowledge. It is necessary that every springhead and brook contributing to the supply be examined, in order to be assured that no underground source of contamination is tainting the water from its start. Again, each stream must be followed down to the compounding reservoir and its various sources of sewage and other contamination noted. This is a work of large proportion and great importance.

Naturally, in the examination of the watershed many avoidable and unavoidable sources of infection will be found. The result of the examination will be the knowledge that the supply is subjected to innumerable sources of contamination, and it becomes a most difficult problem to decide whether this contamination is sufficient to condemn the water. Comparison with other more or less similar water supplies in practical daily use will go far toward solving the question. When, however, this and common sense fail, recourse must be had to chemical and bacteriological examinations. It must be borne in mind, also, that with the natural increase in population on the watershed the points of infection increase in number. Hence, in passing upon a given supply, some provision for the future must be made and the present day supply must be more than just acceptable. It is to be hoped that legal requirements in the future may do much to alleviate future increase of contamination. Nevertheless some increase is unavoidable and the best we can hope for is that future improvements in the methods of water purification may offset this.

The Chemical Examination. — The chemical analysis of the water from a given watershed is limited usually to the determination of the following quantities: — Albuminoid

ammonia, free ammonia, nitrites, nitrates, chlorides, required oxygen and total solids. Other determinations are often made but these in practice are all that are usually needed. Before taking these up in detail, however, a few words in general concerning organic matter and its decomposition may be appropriate.

Organic matter in a given water is not dangerous of itself, as long before it reaches this intensity the palate rebels against using the water. Its presence is of great importance, however, as indicative of the extent to which the supply is being contaminated. If this contamination were due to vegetable matter only, it would be of little importance except in so far as it provided a good culture medium for such bacteria as are contained in the water. On the other hand, if this organic matter contains much nitrogenous material, derived as it usually is from animal matter, we must fear sewage or other dangerous contamination.

In the decomposition of albuminous matter, whether by simple chemical action or as a result of bacterial growth, it is the state or condition of the nitrogen which is most indicative of the stage of the decomposition. The first step in the decomposition is the production of ammonia. This ammonia, as the process goes on, is oxidized into various nitrites, and these, finally, into the ultimate products, the nitrates. When this stage is reached the inorganic matter has become inoffensive, as long before this the carbon, hydrogen, oxygen, sulphur and phosphorus of the albuminous matter have gone off in various gaseous combinations or become combined in stable form. It is the nitrogen, therefore, by reason of the greater importance of this element in the albumin molecule, which is the indicator of the extent of decomposition and oxidation of the organic matter. Let us now return to the chemical determinations referred to above.

Albuminoid ammonia is the ammonia produced from the actual existing nitrogenous matter in the water by an artificial decomposition. This change, which is more or less sim-

ilar to the natural process, is rapidly produced by boiling the sample with a strongly alkaline solution of potassium permanganate, the product being ammonia. This ammonia is then distilled off and its amount determined by Nessler's test. Albuminoid ammonia is a measure of the undecomposed nitrogenous matter of the water.

The free ammonia in the water is determined by simple distillation of the sample and subsequent determination by Nessler's reagent. From what has been said it will be seen that free ammonia indicates the presence in the water of nitrogenous organic matter in the active process of decomposition.

Nitrogen as nitrites is indicated by the depth of the pink color produced when the water is treated with sulphanilic acid and naphthylamine hydrochloride. Nitrites indicate the first step toward oxidation and show that the water is beginning to purify itself.

Nitrogen as nitrates is determined by the depth of the yellow color produced when a sample of the water is evaporated to dryness with a little sodium carbonate and then treated with phenol-sulphonic acid and ammonium hydroxide. Nitrates indicate that the nitrogenous organic matter in the water is now fully oxidized and inert.

Chlorine as chlorides in the water is tested for in the usual way with silver nitrate, using potassium chromate as an indicator. By reason of the large amount of sodium chloride in sewage this determination is very important as indicative of this kind of pollution. As, however, all soils, and, therefore, all waters contain this salt, allowance must be made for the normal chloride content of the water of the given district.

Required oxygen, or oxygen consuming capacity, is determined by measuring the amount of potassium permanganate required to oxidize the organic matter in the sample. From this determination is found the amount of oxygen required to oxidize all the animal and vegetable impurity in the water. It differs from the determination of the free and albuminoid

ammonias in that the oxidation of the vegetable matter is likewise included.

The total solids are found by evaporation to dryness and weighing. If the residue is ignited and then re-weighed, the difference gives the amount of organic matter present (plus, however, some chloride driven off by the heat.) This organic matter includes both animal and vegetable contamination and therefore corresponds in a measure to the determination of required oxygen.

As before stated, the impurities indicated by the above tests, being present in such small amounts as to be measured only in parts per million, can produce absolutely no harmful effect of themselves. They are simply indicators of present or past organic pollution. From them, however, it is impossible to determine the actual amount of organic matter that exists or existed in the water on account of the exceedingly complex and variable composition of such matter. The best that can be done is to measure the decomposition products, either natural or artificial, of such organic matter, and determine by comparison with other good water supplies whether they are within safe limits. An idea of the magnitude of the quantities concerned may be obtained from the table below, given by Dr. A. R. Leeds as a standard for American rivers used for water supply purposes : —

Albuminoid Ammonia.....	.10 to .28	parts per million
Free Ammonia.....	.01 to .12	" "
Nitrogen as Nitrites.....	.003	" "
Nitrogen as Nitrates.....	1.11 to 3.89	" "
Chlorine as Chlorides.....	3.00 to 10.00	" "
Oxygen Consuming Capacity..	5.00 to 7.00	" "

Much information can be obtained from a careful study of the actual and relative values of the various determinations. If the albuminoid ammonia is relatively very high, it indicates that the source of organic pollution of the water is so close at hand that decomposition has scarcely had time to

begin. If the free ammonia and nitrite determinations are relatively high, it indicates active decomposition. If, on the other hand, it is the nitrates that are relatively high, it may be assumed that the source of contamination is more distant and that the water is well able to care for its impurities. Naturally, the more remote the contamination of the water, the less danger there is of its carrying pathological bacteria. If all four of these determinations are high, albuminoid ammonia, free ammonia, nitrites and nitrates, then there is evidently a large amount of contamination present at some point, a conclusion which would be confirmed by the determination of required oxygen being also probably high. It must be borne in mind, however, that a large oxygen consuming capacity in itself may not be at all indicative of danger, as the greater amount of the impurity thus indicated may be due to harmless vegetable matter.

Chlorine, if persistently high, indicates grave danger of sewage contamination or barnyard drainage. A water with high chlorine content must always be looked upon with great suspicion as very likely contaminated by sewage. If it happens that with high chlorine the nitrates are high, while the albuminoid ammonia, free ammonia and nitrites are relatively low, the indications might point to a distant sewage pollution which the water had been amply able to dispose of.

As stated above, the required oxygen is by no means indicative of dangerous contamination at all times. For instance streams flowing from heavily wooded, swampy districts will be found largely charged with vegetable impurity giving a high required oxygen, and yet the animal pollution, the dangerous part, may be very small.

The determination of total solids is not of so much practical importance beyond indicating after ignition the total mineral sediment in the water and furnishing a check on the total organic solids.

The Bacteriological Examination.—The examination of a

water supply from a bacteriological standpoint may vary in extent from the simple counting of colonies to the most detailed determination of species. From the practical side this latter is not necessary, as it is only bacteria indicative of sewage pollution which are of importance. If this class of bacteria is present the water must be viewed with suspicion, for if it contains the ordinary intestinal bacteria it may also contain the typhoid bacillus if there happens to be a case of that dread disease on the watershed. It has long been recognized, although not without question, that the *Bacillus coli communis* is a typical intestinal bacterium and that its presence indicates danger of sewage contamination. It is fortunately a bacterium easy to test for without much expertness in bacteriological laboratory practice.

From the practical sanitary and engineering standpoint the bacteriological examination of a given water may be limited to two determinations—first, the counting of the total number of bacteria irrespective of kind and, second, the testing for the probable presence of the *Bacillus coli communis*.

The method of counting the number of bacteria is so simple and so well known as to need little description. It consists of inoculating plates of nutrient gelatine while soft with measured amounts of the sample (or its dilution) and then allowing the gelatine to harden and the bacteria to develop into colonies visible to the naked eye. Each colony which develops represents one bacterium in the original sample. Of course, it is impossible to set minimum figures for the number of bacteria and in good municipal water supplies they may be found to vary through wide limits. It is seen, therefore, that the simple counting of the bacteria indicates little of itself. A very real value of the determination, however, is in ascertaining the bacterial efficiency of the filters or other purification methods usually used in water supply systems. Here simultaneous bacterial counts inside and outside the filters give their efficiency in very decided terms. Again, daily bacterial counts are of great service in

operating a water supply system because any sudden change in the bacterial count, unaccompanied by some cause, as for instance a rainfall, indicates something calling for examination.

The presence of *Bacillus coli communis* in a given water can only be absolutely demonstrated by the bacteriologist. There is, however, a certain series of preliminary tests which can be made in routine work, which tests decide whether or not the water is to be looked upon with suspicion. If these tests are responded to positively, the water should be immediately turned over to the expert bacteriologist for careful determination of species of bacteria. If the reactions are negative we may rest assured that the water is reasonably free from sewage contamination. There are some eight or ten common tests which may be used, but for practical routine study of the operation of a given water system the following only need be applied:—

1. A certain number of small fermentation tubes are charged with dextrose bouillon (ordinary culture bouillon with a small amount of dextrose added) and each inoculated with 1 cc. of the given sample of water. These are then set aside to ferment and if *Bacillus coli communis* is present gas will form abundantly in some of the tubes. An idea of the number of bacteria present may be formed by observing the relative number of tubes which show the reaction.

2. The amount of gas produced may be expressed in percentages of the length of the closed limb of the fermentation tube. If *Bacillus coli communis* is present the closed limb will be about half full of gas by the end of the third day. The gas will usually all be evolved by the end of the second day. Twenty-five per cent. of gas or seventy-five per cent. of gas will not point to *Bacillus coli communis*, especially if the other tests are negative.

3. The gas formed by *Bacillus coli communis* is usually nearly all evolved during the first twenty-four hours. Read-

ings should therefore be taken of the amount of the gas on each of the three days. Other gas producing bacteria act more slowly.

4. The gas produced by *Bacillus coli communis* is generally assumed to be composed of hydrogen and carbon dioxide in the proportion of $H : CO_2 :: 2 : 1$. To determine this ratio sodium hydroxide is added to the tube, the open end filled to the top with water, the orifice closed with the thumb, the tube tilted back and forth several times to mix, and then all the remaining gas allowed to collect in the closed limb. The residual gas is assumed to be hydrogen (carbon dioxide having been absorbed by the alkali) and the ratio then calculated. If this ratio of $H : CO_2$ approximates $2 : 1$ the reaction is considered positive and the water is not above suspicion.

5. The liquid in the fermentation tube must be pronouncedly acid to indicate the presence of *Bacillus coli communis*.

6. *Bacillus coli communis* grown on nutrient gelatine forms non-liquifying, whitish, leafy colonies showing radial lines.

If the above tests, or most of them, give a positive reaction, the water must be regarded with suspicion and the services of the bacteriologist called in to determine to exactly what extent *Bacillus coli communis* and other intestinal bacteria, both harmful and otherwise, may be present.

The routine application of these tests to a given water supply will soon enable one to become acquainted with the characteristics of the water and to establish a sort of normal. Any sudden or persistent deviation from this normal should be ground for grave suspicion and an investigation should be at once started.

Interpretation of Results. — The question of the weight to be given to the results of the various chemical and bacterio-

logical reactions above noted is an important one. At the outset it must be noted that neither chemical nor bacteriological examinations alone are sufficient to safeguard a water supply. The two classes of tests must go hand in hand, each having various advantages over the other. It may be of interest to consider these points a little in detail.

In the first place, the chemical analysis shows the true chemical nature of the water, something which the bacteriological tests do not do. Again, the chemical tests are usually applied to much larger quantities of the water and, therefore, give a truer "average." As against this, however, the examination is more complicated and, therefore, except in large laboratories, would not be made so often.

As regards the tests more especially indicative of sewage contamination, we have on one hand the chemical test for chlorine and on the other the bacteriological tests for *Bacillus coli communis*. The former is quite simple and very certain. The latter, although not so simple, are probably just as certain by reason of their directness.

As concerns the nitrogenous matter of the water, we may contrast the chemical and bacteriological tests in manner following: The two ammonias, nitrites and nitrates give a measure of the organic matter in the water. This organic matter must serve at one or another time as a good culture medium for whatever bacteria there may be in the water. The relative proportion of these items tells us whether the medium is in good, active condition or becoming exhausted. It is reasonable to assume the bacterial activity greater when the chemical activity is greater, as occurs in the early stages of decomposition; that is, during the free ammonia and nitrite stages especially. This is an assumption based on the chemical determinations. On the other hand, the gelatine plate cultures and counting of colonies give a direct count of the number of bacteria, and one determination should confirm the other.

Again, the chemical examination is much more accurate

and uniform in its results, both by reason of the larger quantities dealt with as well as by reason of the intrinsic accuracy of the methods. One reason for this accuracy is that the chemical method is not affected by any sudden, unavoidable focus of bacterial activity that may appear at any moment and as suddenly and unavoidably vitiate the results of the bacteriological determinations. To offset this, however, the latter method has the quick and specific fermentation tube test for directly indicating the presence of sewage contamination through the recognition of one of the prominent intestinal bacteria, the *Bacillus coli communis*.

From what has been said it is evident that neither the chemical nor bacteriological method alone is sufficient for the proper examination and study of a water supply. Routine daily tests by both methods, using for instance, chemically, nitrites and chlorides, and bacteriologically, colony counting and the fermentation tube, are probably all the tests necessary to safeguard an existing water supply already found satisfactory. Any unexplained abnormality in the reactions should at once be met by a more thorough examination. As long as things go uniformly along little need be feared. The tests are so simple that any intelligent person can perform them in routine work and the expert need only be sent for when the tests indicate danger. No community should be satisfied to go ahead day after day using a given water without having it methodically subjected to these simple routine tests.

CONCERNING *NAVICULA SOCIALIS*.

BY T. CHALKLEY PALMER.

In the original notice* of *Navicula socialis*, Palmer, emphasis was laid on the peculiar grouping of the frustules into motile chains consisting, as a rule, of four individuals. It was remarked that "a history of the life-cycle of this diatom, which will necessarily include an account of the formation of these groups, is much to be desired." Since the date of that publication, many new occurrences of the species have been noted; and while the life-cycle is at this time far from being completely understood, further study has served but to confirm the first conclusion that the unprecedented grouping into blocks of four is not fortuitous, occasional or temporary, but a constant and essential characteristic. The origin of these groups is still to be explained, but their persistence is now well authenticated.

That the frustules continue in this grouping is shown by the fact that groups have been collected during every month of the year in a certain spring in the neighborhood of the writer's home. They occur there but sparsely in association with a strong and persistent growth of *Navicula Iridis*. In that isolated and sheltered pool of living water the little groups of four continue their placid existence, undisturbed by the snows and fierce frosts of winter, the thaws and floods of spring, the desiccating heats of summer. Immersed in a great gulf (about ten gallons) of purest liquid of a nearly uniform temperature, and well shaded from the direct sun-rays, the trouble of the seasons passes them by.

The essential nature of the grouping is shown first of all, as it seems to me, by the fact that, while the length of the group will vary from 120μ down to 60μ , the *frustules of a given group are all of the same size*. These groups must therefore be composed of individuals of a common and simul-

* Proc. Acad. Nat. Sci., Phila., 1910, p. 460.

taneous origin, and of a common history as regards that reduplication to which the progressive decrease in size is due. This will then mean, that whatever the origin of the group may be, reduplication within the group is *simultaneous*.

This deduction is now confirmed by observation. Mr. F. J. Keeley on May 28th, 1911, collected *N. socialis* at Elam, Delaware County, Pa., and found numbers of groups in process of reduplication. The groups, being mounted in balsam after burning on the cover glass, inevitably lay flat to the view, so that the doubling of the frustules was not at once evident; but by careful focussing it was possible to bring into view the two old valves at top and bottom, and the two new valves in the body of each of the four frustules. Moreover, an anomalous or unusual group of eight, in one of Mr. Keeley's mounts, shows all of the eight in simultaneous division. Following this observation, I have made new examination of my own mounts of the species, and have found several instances of the same condition. I have yet to find a case where only one or two or three of the individuals of a group are in this state. Dislocated frustules (in material that has been strongly boiled) frequently exhibit, in girdle-view, the aspect of reduplication familiar in other species, so that we may safely say that the main facts of reduplication of valves in this species are now clear. Subdivision is as usual so far as concerns the individual frustule, and simultaneous in the members of a given group. The intimate nature of the union is thus made evident, and brings to mind the "group consciousness" of the psychologists. Mr. Keeley further refers, in an informal communication, to the curious alternation of the bending of the raphe terminations in the neighboring valves of a given group, as is shown in the original figure.* This was carefully indicated by Miss Winchester, the artist, as a noticeable characteristic, general if not uniform. Mr. Keeley has made countings, estimates

* Proc. Acad. Nat. Sci., Phila., 1900. Pl. XXXV, Fig. 1.

that over nine groups in ten show this alternation, and thinks all the circumstances point to a common origin and a common experience for each frustule of a given group.

Of prime importance, and to my thinking, of surpassing interest, is the *smooth cöoperation of the four cells in locomotion*. The group proceeds in an orderly manner, and as by common consent, without more appearance of cross-purpose between its members than is to be seen sometimes between the two ends of the same cell in isolated diatoms. For the most part, the tabular groups move along the smooth surface of the slide in straight or gently curving lines, making trails quite similar to those already mapped in these PROCEEDINGS* for isolated frustules. On occasion the motion is reversed, or again the group may revolve on one corner as a pivot (owing to a sudden spurt of activity in one or two cells perhaps) and so start off in a new direction. There seems to be quite as much cöoperation, quite as much simultaneous effort in the same sense, as is observed, for instance, in the frustules of a group of *Nitzschia paradoxa*. But unlike that diatom, *N. socialis* continues for long periods moving in the same direction, resembling in this its own relatives in the genus *Navicula*, but still more *Eunotia major*.

The common purpose, if one may so name it, sometimes shows itself in unexpected and surprising ways. When a group meets a firm obstacle squarely in its path, such as a grain of sand too firmly placed to be moved aside or pushed ahead, it will often come to rest for a moment, back away a short distance and return on the same or on a slightly different track. This manœuvre may be repeated a number of times, until perhaps the sand grain is no longer squarely "head-on," but partly to one side and in contact with but one of the frustules, at a corner of the group. The whole group will now gradually tilt itself on its thin edge, draw in against, and seem to grasp, the sand with that one of its own

* PROCEEDINGS, Vol. II, p. 128 et seq. ; Vol. III, p. 70 et seq.

flat surfaces which has been in contact with the slide, crawl on and around the obstruction in that position, and come down again beyond, flat once more upon the slide. It then often proceeds persistently away in much the same direction it held before all this trouble with the sand-grain.* These evolutions remind one most forcibly of the tactics of *Eunotia major* under similar conditions; and it is further to be added, that like the *Eunotia*, *N. socialis* is capable of crawling up the vertical walls of a bottle, and may even move for a time on the under side of a cover glass. In this last position, however, it would not appear as securely placed as some other diatoms, and *Navicula Iridis* frequently pushes it loose, so that it sinks down through the water to the slide.

Having now, as I believe, shown the permanent and essential nature of the grouping during the whole of the vegetative period, I desire to suggest a working hypothesis as to the origin of these groups, unique as they appear to be among diatoms.

It is well known that many, if not most, diatoms cast off their silicious parts on reaching a certain minimum length after successive reduplications, and by one or another process resume their original size. Whether with or without conjugation with other individuals, spore-like bodies are formed, which after varying transformations in different genera produce one or two new, large diatoms that quickly secrete for themselves new valves according to the pattern proper to the particular species. Several types of this rejuvenescence have

* I have not given here a description of an isolated occurrence. The above, or its equivalent, has been observed a number of times. For the benefit of those numerous writers who prefer to have all the motile phenomena reduced to terms of "reactions" and "tropisms," I would suggest, with the diffidence proper to one unskilled in such matters, that *N. socialis* reacts positively to the near side, and negatively to the far side of the grain of sand. In this connection I cannot easily forbear the further remark, that we are some distance away, in this voracious account, from motile theories of inward or outward streams of gas, water or "gallerte!"

been studied by Mr. Thwaites and others. Now this part of the cycle is quite unknown in the case of *N. socialis*; and as the grouping is exceptional, very probably the process that leads to it will be found not quite identical at every point with any of those already described. My suggestion is this:—

On reaching the minimum length, which so far as observed is 60μ , the diatoms of a given group throw off their valves and enter the sporing condition. At this stage they may appear as a small mass of jelly containing amber-colored bodies and bedecked on the surface with the cast-off valves. The number of amber-colored bodies may be at first four, or eight, or by a bare possibility a multitude, according to the plan of reproduction which is followed. I suppose, however, that ultimately, either with or without conjugation, certain rather large spores are formed, each surrounded by its own gelatinous envelope, which may be called zygosporos or auxosporos, in accordance with their history. Each spore then divides first into two halves, and these halves again subdivide once, so that four bodies are produced after the manner of *Tetraspora*. These four final spores, still within a common gelatinous sheath, then shape themselves into four new and full-sized diatoms; and having aligned themselves into a typical group, still surrounded by the jelly—which now becomes more thin and functions as the coleoderm—they move off to meet their further destiny as *N. socialis* again.

This tetraspore conception seems the only obvious hypothesis at present. Its correctness may be most hopefully tested where the species is found growing in real abundance in some sheltered water close at hand, where the full circle of development may be followed continuously. Rank growth under such conditions I have not yet seen, and the richest gatherings so far are from the far-away Fall Mountain, in Connecticut.* However, I have happened to see a few bodies which may easily have been the spores of this species. They

*Mr. W. A. Terry.

occurred on the lip of a spring in Media, where *N. socialis* occurs, but only sparingly, and among a perfectly overwhelming mass of other diatoms. They were collected on two different occasions, both in the month of April. They were always scarce in the gathering, but their unusual appearance was such as to arrest the attention at once. They consisted in each observed case of crystal-clear but dense and visible jelly masses, containing each either two or four ovoid, amber-brown, translucent, spore-like bodies, precisely the color of a perfectly healthy *Navicula*. In one instance there were four spores — if spores they were — arranged in one plane as at the corners of a square. These bodies could not be proved to have any relation with *N. socialis*. Paucity of material and lack of an effective technique for producing further development, combined for failure. But they were like nothing I have seen described, and I have always felt a perfect confidence that they belonged to some diatom, and just as constantly I have suspected that they pertained to *N. socialis*.

It is along this indicated line that I look for an elucidation of the groups of four. I desire in this matter the help of those diatomists who are engaged in the study of the life-histories of these organisms. Here is a chapter still to be written, and it cannot fail to prove of great interest.

THE SPEECH OF INSECTS.

BY SANFORD OMENSETTER.

The "speech" of insects? Why not? Although by development unfit to put the crude processes of low mentality into language, their notes at times respond to the promptings of fear, distress or danger. But 'tis mainly when moved by the tender passion that insects break forth into audible expression.

Among butterflies and the night loving moths, the gaudy colors of most species serve to attract the sexes. The sombre hued crickets and other weak voiced nations of the grass; the cicada, half hidden in the summer foliage; and others, less seen and less familiar, to whom nature has denied enticing raiment, must needs have other means to show their whereabouts, and to the males of these the law of compensation has decreed what in the human corresponds to speech.

This article claims no warrant of originality. The observations are in the main those of others. A slight attempt to arrange them has been made during the few spare moments of a busy life.

Some sounds of insects have roused much dread among the superstitious. Probably the most alarming, common to the European genus *Anobium*, has been the noise issuing from old timber or old books, resembling the ticking of a watch. Legend credited the insect with foretelling the coming of the rider on the pale horse, and hence it was commonly called the death watch. According to Latreille, the male (and in this case also the female), at the period of mating, strike many times successively and rapidly with their mandibles the wainscot where they are placed, and mutually answer each other's signal, and such is the cause of the ominous ticking. Sir Thomas Browne considered the reputation of the death watch of great importance, and remarked that the man "who could eradicate this error from the minds of the people, would save from many a cold sweat

the meticulous heads of nurses and grandmothers," as many such are firm in the belief that

"The solemn death watch clicks the hour of death."

Dean Swift, whose trenchant pen in "Gulliver's Travels" laid bare the foibles of his time, tried to perform this useful task by means of ridicule. The antidote was prescribed as follows : —

"A wood worm

That lies in old wood, like a hare in her form,
With teeth or with claws, it will bite, it will scratch ;
And chambermaids christen this worm a death-watch ;
Because, like a watch, it always cries click.
Then woe be to those in the house that are sick !
For, sure as a gun, they will give up the ghost,
If the maggot cries click when it scratches the post.
But a kettle of scalding hot water injected,
Infallibly cures the timber affected :
The omen is broken, the danger is over,
The maggot will die, and the sick will recover."

In the above the larva is blamed for the disturbance. Later observers incline to charge it to the mature insect.

Acherontia Atropos, a British species more generally known as the death's head hawk moth, has been a source of terror to the superstitious. Bearing upon the upper side of the thorax the figure of a human skull, it lacks but the cross bones for the hall mark of Captain Kidd. In habit the moth is known to have patterned after the dead freebooter, in that it has viewed the honeyed content of the bee hive as its lawful prey. Bees are jealous of such intrusion, but in this case the pirate, without bodily harm, gets away with the goods. That same mournful cry, likened to the plaint of a captive mouse, which, taken with death's symbol, has roused the alarm of many a country swain, overcomes the angry chidings of the bees, and the despoilation proceeds with impunity. However, when the death's head hawk moth was introduced by the learned Huber into a nest of humble bees,

they were not affected by it, like the hive bees, but attacked it and drove it out of their nest, and in one instance their stings proved fatal.

The caterpillar of the moth just mentioned is credited with being able, when disturbed, to produce by drawing back rapidly a sound resembling the crack of an electric spark. In either of the cases cited, the source of the noise does not seem to have been very well determined.

Reference to the two insects mentioned has appeared so often as almost to have become classic.

The species of the genus *Cicada*, called by the ancient Greeks—by whom they were often kept in cages for the sake of their song—*Tettix*, seem, according to a distinguished writer, to have been the favorites of every Grecian bard from Homer and Hesiod to Anacreon and Theocritus. Supposed to be perfectly harmless, and to live only upon the dew, they were addressed by the most endearing epithets, and were regarded as all but divine. One bard entreats the shepherds to spare the innoxious tettix, that nightingale of the Nymphs, and to make those mischievous birds, the thrush and black-bird, their prey. "Sweet prophet of the summer," says Anacreon, addressing this insect, "the Muses love thee, Phœbus himself loves thee, and has given thee a shrill song; old age does not wear thee out; thou art wise, earth-born, musical, impassive, without blood; thou art almost like a god." So attached were the Athenians to these insects that they were accustomed to fasten golden images of them in their hair, implying at the same time a boast that they themselves, as well as the *Cicadæ*, were children of the earth. They were regarded indeed by all as the happiest as well as the most innocent of creatures—not, we will suppose, for the reason given by the saucy Rhodian Xenarchus, when he says,

"Happy the cicadas' lives,
Since they all have voiceless wives."

If the Grecian tettix or cicada had been distinguished by

a harsh and deafening note, like those of some other countries, it would hardly have been an object of such affection. That it was not is clearly proved by the connection which was supposed to exist between it and music. Thus the sound of this insect and of the harp were called by one and the same name. A cicada sitting upon a harp was a usual emblem of the science of music, which was thus accounted for: When two rival musicians, Eunomus and Ariston, were contending upon that instrument, a cicada flying to the former and sitting upon his harp supplied the place of a broken string and so secured to him the victory. To excel this insect in singing seems to have been the highest commendation of a singer; and even the eloquence of Plato was not thought to suffer by a comparison with it. At Surinam the noise of a certain cicada was supposed so much to resemble the sound of a harp or lyre, that it is there called the harper. Whether the Grecian cicadas at present maintain their ancient character for music, we cannot say.

Those of other countries, however, have been held in less estimation for their powers of song; or rather have been execrated for the deafening din that they produce. Virgil accuses those of Italy of bursting the very shrubs with their noise, while a modern traveler observes that this species, which is very common, makes a most disagreeable, dull chirping. It is reported that the Brazilian cicadas sing so loud as to be heard at the distance of a mile. This is as if a man of ordinary stature, supposing the powers of his voice increased in the ratio of his size, could be heard all over the world. So that Stentor himself, compared with these insects, becomes a mute.

How appropriate on a sultry summer day is the languid "z-z-z-z-z-z-z" of our native annual cicada, erroneously called "locust!" The very lassitude induced by extreme heat seems to have focussed in the lament of this ubiquitous insect. But occasionally the monody is staccatoed by a wail of terror as the artist becomes the booty of its arch

enemy, the sphex insect, "locust catcher," "sand hornet," or "digger wasp." At times of normal humidity the cicada becomes more than usually strident and voiceful. In this regard they can scarcely be excelled by the cicadas of northern Africa, of which Dr. Shaw, a traveler of a former generation, thus complains: "In the hotter months of summer, especially from mid-day to the middle of the afternoon, the cicada, tettix, or grasshopper (as we falsely translate it), is perpetually stunning our ears with its most excessively shrill and ungrateful noise. It is in this respect the most troublesome and impertinent of insects, perching upon a twig, and squalling sometimes two or three hours without ceasing, thereby too often disturbing the studies or short repose that is frequently indulged in these hot climates at those hours. The tettix of the Greeks must have had a quite different voice, more soft, surely, and melodious, otherwise the fine orators of Homer, who are compared to it, can be compared to nothing better than loud, loquacious scolds."

There are in the United States, according to the late Dr. Henry C. McCook, four species of cicada, two of which are annual in appearance and two periodical. Other writers incline to classify into more species the annual visitor, and are almost persuaded of the existence of but one long termmer of two different periods (thirteen or seventeen years) the variation occurring by its holding respectively a southern or a northern habitat. Transplanting of the eggs of the two periodical species has not as yet sufficiently verified the last proposition. By far the better known in Delaware County is the annual *Cicada pruinosa*, which usually proclaims its arrival during July.

Most insects undergo a complete metamorphosis: that is, they exist as the egg, the larva, the pupa (which may be regarded as a period of hibernation) and the perfect insect. Not so with the cicada. It is in motion from the time of hatching until, after a short, ethereal existence, it croons its requiem among the trees.

Craving indulgence for this slight digression, we bespeak your patience for a somewhat extended history of the seventeen year cicada. Our earliest account of this insect is to be found in Morton's "Memorial," wherein it is stated that "there was a numerous company of flies, which were like for bigness unto wasps or bumble bees," which appeared in Plymouth, Massachusetts, in the Spring of 1633. "They came out of little holes in the ground and did eat up the green things, and made such a constant yelling noise as made the woods ring of them, and ready to deafen the hearers." How, from the structure of their mouths they ate vegetation, the narrator fails to explain. According to Peter Collinson (1762) they appeared in Pennsylvania in incredible numbers in the middle of May, and made such a continual din from morning to evening that people could not hear each other speak. With the single exception of its long earthly imprisonment, the course of development of the seventeen year cicada may be taken as typical of the members of the genus.

The eggs are one-twelfth of an inch long, obtuse at each end, and of pearl white color. In the act of laying the female selects a branch of moderate size. Facing the tip of such a branch, she bends her piercer, and setting in motion the saws in line with the grain of the wood, detaches splinters so as to form a lid to the perforation, which extends to the pith. The cavity is enlarged to receive ten to twenty eggs, which are laid in pairs, separated by fibre, and with one end pointing upward. The preparation and filling of a single nest occupies some fifteen minutes, a dozen or more being located on a single branch. The cicada flits from tree to tree until her store of 400 or 500 eggs is exhausted, when she soon dies. The period of incubation is variously given at from fourteen to fifty-two days.

The young cicadas when liberated from the shell are exceedingly lively, and their movements are nearly as quick as those of ants. In a few moments instinct impels them to reach the ground. How shall they avoid the many dangers

from predatory birds or insects which might intercept them in a tedious journey down the tree? They merely move to the side of the branch, loosen their hold, and more or less gracefully alight on terra firma.

Immediately, by means of their mole-like forefeet, they burrow in the soil, following the roots of plants, to which they attach themselves by their beak, drinking long and deep from the springs of vegetable life. Down in the depths of these Plutonic abodes they await the summons which bid them mount upward, an impulse they cannot understand, but dare not disobey. As the time of their transformation approaches they ascend, forming cylindrical passages, filled below with earthy matter removed by the insect in its progress, but open to the extent of six or eight inches from the top. In these retreats they linger several days, mounting to the surface in fine weather for air and sunshine, and peeping forth upon the broad world upon which they soon shall enter. In wet situations the wary insect is said to erect a turret, in which haven of refuge it remains until the day of deliverance.

When at length the grubs have gained the proper strength they issue at night in great numbers, crawling up objects to which they can fasten securely by their claws. Presently the skin becomes dry, by repeated exertions a rent is made in the back and the cicada emerges. Taking a few steps it rests, the flexible wings obtain full power and dimension, the superfluous moisture evaporates, and with the morning sun it fans the summer breeze a queen of air.

Within two weeks they begin to lay their eggs, and in six weeks another appearance of the seventeen year cicada has passed into history.

These visitations do not occur simultaneously in all parts of the land, but in various years, in some sections, their coming is awaited by the timid with varying degrees of dread. During the summer of 1902 they were much in evidence throughout eastern Pennsylvania, northern New Jersey, Maryland, Delaware and the State of Illinois. On May 25th

of that year the advance guard was quite plentiful in the privet hedge on the west side of Orange street, north of the railroad, in the borough of Media. In 1885, the same ground being occupied by Osage orange, they were there found in great abundance, as were they also in the thicket north of the road leading from Ridley Creek to the Black Horse, in Middletown Township. In 1902 they were numerous in the wood southwest of Media station, and still more so among the chestnut trees at "Idlewild."

As early as 3 A. M. the subdued cadence of the males rolls tremulously on the morning air—a low, monotonous murmur, which changes before they perish to a sound somewhat resembling the running of a sewing machine. In calling to his mate the abdomen of the male is raised and lowered in unison with the sound of "*wa-a-o*," plaintively drawn out.

The musical apparatus of the seventeen year cicada can readily be seen just behind the wings, and is a membrane stretched over a cavity and alternately tightened and released by muscular action from within.

In the neighborhood of Media the chestnut seemed to be the favorite for oviposition. The eggs, however, have been found in so astringent a tree as the black walnut, and even in the stem of the golden rod. Where many perforations are made the branch droops and dies, giving an unsightly effect, and preventing development of the eggs.

The seventeen year cicada is greedily pursued by different birds, and under the various forces combined against it the fate of the American bison seems to await these insects. Fowls delight in them, with the penalty, upon authority of Dr. Harlan, of Philadelphia, of producing eggs with colorless yolks. A most relentless enemy is the sphex insect, before named, which keeps its burrow well supplied with unwary victims.

This cicada is, in length of days, the longest lived of insects. Seventeen years beneath the soil—a few weeks of air and sunshine as the perfect insect! What a contrast to the

general law of the animal world that life's span is five times the period of growth. Imagine a cicada 85 years of age.

Fitting climax, surely, to its long walk in darkness may be this apostrophe of the sensual Anacreon : —

Happy creature, what below
Can live more happily than thou?
Seated on thy leafy throne,
(Summer weaves thy verdant crown,) ·
Sipping o'er the pearly lawn
The fragrant nectar of the dawn,
Little tales thou lovest to sing,
Tales of mirth—an infant king.

Crickets are *par excellence* the musicians among insects. Fabled in song and story, their cheery monodies have been the theme of writers since distant times. The blind Milton chose for his reveries the spot where crickets were wont to linger,

“Where glowing embers through the room
Teach light to counterfeit a gloom,
Far from all resort of mirth,
Save the cricket on the hearth.”—*Il Penseroso*.

Not the least among the writings of Charles Dickens, that master mind that laid bare the heart and thought of man, is “The Cricket on the Hearth.” The rather strident cry of the house cricket brings to memory visions of the old fashioned fireplace, the cosy chimney corner, the flickering glare from hickory logs. Around such scenes as these, familiar enough in pioneer days, have the destinies of nations been builded.

Other species shun the busy haunts of man. The mole cricket spends his life mainly within burrows dug by his mole-like fore legs, and is seldom seen. Toward autumn the male essays to sing, and his effort has been reduced to cold type, *u* being long, as follows : —

Gru, gru, gru, gru, gru, gru, gru,

ad lib. This is the refrain of the so-called “Fall cricket.”

The common field crickets are frequently noisy at night. According to Scudder the note is a shrill one, and is said to be pitched at *c* natural, two octaves above middle *c*. Its nearest approach to English has been placed as

Crrri, crrri, crrri, crrri, crrri.

Probably the most prevalent night song is that of the snowy tree cricket. Riley penned a good description when he said that it "is intermittent, resembling a shrill

Re-teat, re-teat, re-teat,

with a slight pause between each." The recluse of Walden termed it "slumbrous breathing," while Hawthorne describes it as "audible stillness," and remarks that "if moonlight could be heard it would sound like that." Perhaps he fancied Luna's beams on Taj Mahal.

The instrument upon which the male cricket plays is comprised of strong nervures or rough strings in the wing cases, by the friction of which against each other a sound is produced and communicated to the membranes stretched between them, in the same way that the vibrations caused by the friction of the finger upon the tambourine are spread over the surface.

"Sounds," it is well observed by the natural historian of Selborne, "do not always give us pleasure according to their sweetness and melody; nor do harsh sounds always displease. Thus the shrilling of the field cricket, though sharp and stridulous, yet marvellously delights some hearers, filling their minds with a train of summer ideas of every thing that is rural, verdurous and joyous."

"Sounds inharmonious in themselves and harsh,
Yet heard in scenes where peace for ever reigns,
And only there, please highly for their sake."

—Cowper, "Task," Book I.

This circumstance, no doubt, caused the Spaniards to keep

them in cages, as are singing birds. Gilbert White found that if supplied with moistened green leaves they will sing as merrily and loudly in a paper cage as in the fields.

Swammerdam entertained a different notion of their music. "I remember," he says, "that I once saw a whole field full of these singing crickets, each of which had dug itself a hole in the earth two fingers deep, and then, sitting at the entrance thereof, they made a very disagreeable noise with the creaking and tremulous motion of their wings. When they heard any noise they immediately retired with fright into their little caverns."

The house cricket or hearth cricket, of Europe, is not common on the western continent except in Canada, but two or three species of field crickets are occasionally found in houses in the United States. The common black cricket, found in grassy pasture lands or fields, lives in burrows under the ground, issues sometimes during the day, but more usually at night to feed, and takes blades of grass back into its burrow. The eggs are laid in the autumn, generally in the ground, and are hatched the following summer. The mole crickets live always under the ground and feed upon the tender roots of forage plants, while the tree crickets are, as their name suggests, arboreal in their habits.

The name cricket is derived from the imitative French popular name, "cricri," and similar descriptive names are applied to it in many foreign tongues.

Six weeks from katydid to frost. Such is the idea commonly held by many when the call of this insect first breaks the stillness of a July evening. The time worn assertion and denial of "Katy did" and "Katy didn't" seem in these parts to have changed to a simple, non-committal "Katy." In other words, their dialogue generally consists of two syllables rather than three. "These two notes," says Scudder, "are of equal (and extraordinary) emphasis, the latter about one-quarter longer than the former; or, if three notes are given, the first and second are alike, and a little shorter than

the last. The notes are repeated at the rate of two hundred per minute, and, while the interval between the two series of notes varies to a certain degree, it is seldom greater than two and one-third seconds or less than a second and a quarter."

This is Mr. Scudder's attempt to English the call of the katydid:—

xr! xr! or xr! xr! xr!

which to the lay mind conveys the idea of a rip saw coming in contact with a nail. The sound is really more agreeable when heard proceeding from its natural source.

The long horned grasshoppers, or green grasshoppers, with which are included the katydids, are among the most musical of our orthopterous insects. They are delicately built, much more fragile than the short horned grasshoppers, and are noted for their powers of song. The males are generally furnished with a musical contrivance consisting of a peculiar development of the veins and membrane at the base of the wing cover. The more frequently occurring forms are known as meadow grasshoppers.

Brunelli, an Italian naturalist, experimented with some long horned grasshoppers. He kept several in a chamber, which continued their crinking song during the whole day; but the instant they heard a knock at the door they were silent. He subsequently invented a method of imitating their sounds, and when he did so outside the door, at first a few would venture upon a soft whisper, and by and by the whole party burst out in chorus to answer him; but upon repeating the rap at the door, they instantly stopped again as if alarmed. He likewise confined a male in one side of his garden, while he put a female in the other at liberty, which began to leap as soon as she heard the crink of the male, and immediately came to him, an experiment which he frequently repeated with the same result. It is remarkable that the males alone of these insects are musical; for "the females," as Swammerdam long ago observed, "of locusts, grasshoppers, and others, make no noise."

Many of the social insects indulge in peculiar noises while at their various employments—doubtless satisfied comment on the favorable progress of their work. If we apply an ear to the nest of an humble bee or to a bee hive, a hum of varied intensity may be perceived. An enthusiast named Gœdart claimed that in every humble bee's nest there is a trumpeter, who early in the morning ascends its summit, vibrates his wings, and buzzing for a quarter of an hour, rouses the denizens to daily toil. Nearly every one who recognizes the blue mud wasp and has watched this diligent mason in the construction of its adobe nesting cells, may have noticed the singular but complacent sound which lightens its labor, and may be heard at quite a distance.

The queen of the honey bee has been famed for a curious noise which produces an extraordinary result upon her subjects. It has been stated that at times, just before bees swarm, instead of the monotonous hum usually heard, and even in the middle of the night, if the ear be placed close to the entrance of the hive, a sharp, clear note may be detected, which seems to be caused by the vibration of the wings of a single bee. This, it has been claimed, is the harangue of the new queen to her vassals, to imbue them with courage to lay the corner stone of a new empire.

The praying mantis, the European *Mantis religiosa*, when alarmed and in an attitude of defense, according to M. Goureau, an entomologist of France, rubs the sides of the abdomen against the interior borders of the wings and elytra, so as to produce a noise like that of parchment rubbed together. The monkish legend tells us that St. Francis Xavier, walking one day in a garden and seeing an insect of the *Mantis* genus moving along in its solemn way, holding up its two fore legs as in the act of devotion, desired it to intone the praise of Deity. The legend adds that the saint immediately heard the insect carol a fine canticle with a loud emphasis. *Mantis religiosa* has been introduced into northern New York, probably in the egg state on imported nursery

stock. That its mind sometimes runs in material channels may be gleaned from the report of an observer on a typical menu: "One Sunday a green mantis ate three grasshoppers, each seven-eighths of an inch long, a daddy long legs, and then tackled another mantis, and I was obliged to interfere between them." A Japanese species has of late years made its appearance about Philadelphia, and is said to be becoming numerous. A native species, *Stagmomantis carolina*, is common throughout the southern United States, extending as far north as New Jersey.

Some insects have been noted for a peculiar method of calling, commanding, or giving an alarm. Observation has been made of a noise made by the neuters or soldiers among the white ants, by which they keep the laborers, who answer it by a hiss, upon the alert and to their work. This noise, which is produced by striking any substance with their mandibles, has been described by Smeathman as a small, vibrating sound, rather quicker and shriller than the ticking of a watch. It could be distinguished, he says, at the distance of three or four feet, and continued for a minute at a time with very short intervals. When any one walks in a solitary grove, where the covered ways of these insects abound, they give the alarm by a loud hissing, which is heard at every step. "When house crickets are out," says Mr. White, "and running about in a room at night, if surprised by a candle, they give two or three shrill notes, as it were for a signal to their followers, that they may escape to their crannies and lurking-holes to avoid danger."

Many beetles when captured manifest their alarm by the emission of a shrill, sibilant or creaking sound — likened by some to the chirping of young birds — produced by rubbing their elytra with the extremity of their abdomen. This is the case with some of the chafers and others of the lamellicorn beetles. The burying beetle and many other Coleoptera produce a similar noise by the same means. When this noise is made the movement of the abdomen may be perceived, and if

a pin is introduced under the elytra it ceases. Long after many of these insects are dead the noise may be caused by pressure. The capricorn tribes emit under alarm an acute or creaking sound — which one writer calls querulous, and another compares to the braying of an ass — by the friction of the thorax, which they alternately elevate and depress, against the neck, and sometimes against the base of the elytra. Because of this, one species is in Germany termed “the fiddler.” Two other coleopterous genera make their cry of “Touch me not” by rubbing their thorax against the base of the elytra. Another beetle does the same by the friction of its legs against each other. And, doubtless, many more Coleoptera, if observed, would be found to express their fears by similar means.

In the other orders the examples of cries of terror are much less numerous. A certain bug when taken emits a sharp sound, probably with its rostrum, by moving its head up and down. Ray made a similar remark with respect to another bug, the cry of which he compares to the chirping of a grasshopper.

So far as regards the cries of joy or sorrow of insects, there is little to be noted. That pleasure or pain makes a difference in the tones of vocal insects is not improbable, but our organs of hearing are not fine enough to catch all their different modulations. When Shirach had once smoked a hive to oblige the bees to retire to the top of it, the queen with some of the rest flew away. Upon this, those that remained in the hive sent forth a most plaintive sound, as if they were all deploring their loss. When their sovereign was restored to them, these lugubrious sounds were succeeded by an agreeable humming, which announced their joy at the event. Huber relates that once when all the worker brood was removed from a hive, and only male brood left, the bees appeared in a state of extreme despondency. Assembled in clusters upon the combs, they lost all their activity. The queen dropped her eggs at random, and instead of the usual

active hum, a dead silence reigned in the precincts of the hive.

In addition to sounds of communication, various noises are caused when insects are feeding or flying. The action of the jaws of a large number of chafers produces a noise resembling the sawing of timber; that of the locusts has been compared to the crackling of a flame of fire driven by the wind—indeed the collision at the same instant of myriads of millions of their powerful jaws must be attended by a considerable sound. The timber borers also, the stag horn beetles, and particularly the capricorn beetles—the mandibles of whose larvæ resemble a pair of mill stones—most probably do not feed in silence. A little wood louse—which on that account has been confounded with the death watch—is said also, when so engaged, to emit a ticking noise. Certain flies seen in Spring, distinguished by a very long proboscis, hum all the time that they suck the honey from the flowers; as do also many hawk moths, particularly that called from this circumstance the humming bird, which, while it hovers over them, unfolding its long tongue, pilfers their sweets without interrupting its song. The giant roach, which abounds in old timber houses in the warmer parts of the world, makes a noise when the family are asleep like a pretty smart rapping with the knuckles—three or four sometimes appearing to answer each other. On this account in the West Indies it is called the “drummer,” and they sometimes beat such a reveille that only good sleepers can rest for them. As the insects of this genus generally come forth in the night for the purpose of feeding, this noise is probably connected therewith.

MINUTES OF THE INSTITUTE.

FEBRUARY 2, 1911.—Regular monthly meeting, with Vice President Henry L. Broomall in the chair. Reports of Curators and committees and current business. Donations to the library were announced as follows: "Psychology," by William James; "Delaware County Republican," file of 1835-39. Dr. H. H. Furness, of Wallingford, Pa., presented to the museum an ear of maize of unusual form, a complete description of which will be found in these PROCEEDINGS, Volume VI, Number 2. C. M. Broomall explained by diagram the theory of the curved flight of a ball, by which it curves in the direction of motion of the front of the ball. The meeting closed with a discussion on light pressure and its effects. On motion adjourned.

FEBRUARY 23, 1911. — Adjourned meeting. Lecture, "Poetry of the Sea," by Prof. Wilkie Nelson Collins, of the University of Pennsylvania.

MARCH 2, 1911. — Regular monthly meeting, with President T. Chalkley Palmer in the chair. Reports of Curators, committees and current bills. Albert W. Barker was elected to membership. Donations to the library were announced as follows: Two volumes of "Smithsonian Miscellaneous Collections"; eighteen volumes of United States "Geological Survey Bulletins" and "Water Supply Papers." C. M. Broomall exhibited some cultures of bacteria from the Media water supply and spoke of their significance. President Palmer by request gave a short account of his recent visit to the Royal Microscopical Society (London) and the courteous treatment he had received. He referred to the Society's collection of historic microscopes as being of especial interest. President Palmer reported having found among a collection of fossil diatoms from the middle Neocene of Georgia a form evidently identical with that described recently by him as *Navicula socialis*. Meeting adjourned.

MARCH 9, 1911. — Adjourned meeting. Lecture, "Our Foreign Possessions," by Major Jesse M. Baker.

MARCH 23, 1911. — Adjourned meeting. Illustrated lecture, "Across the Continent and the Canadian Rockies," by Dr. E. D. Fitch.

APRIL 6, 1911. — Regular business meeting, with President T. Chalkley Palmer in the chair. Reports of committees and usual current business. William Taylor, Esq., of Media, was elected to membership. Donations to the library were announced as follows: "North American Ophiurians," "Contributions from the U. S. National Herbarium," and a number of French pamphlets on insects. On motion it was decided that the Institute purchase the eleventh edition of the "Encyclopædia Britannica," and a committee was appointed for that purpose. The annual nomination of officers was held. Edgar T. Miller was elected to life membership in recognition of his long and valuable services as chairman of the Board of Curators. Dr. Anna E. Broomall presented a large collection of Rocky Mountain flora and also a book of mounted ferns from India. C. M. Broomall reported results of current systematic bacterial examinations of Media water. President Palmer spoke concerning the various theories of the rôle of light in building up carbohydrates in the vegetable cell. H. L. Broomall spoke of the tendency in our schools to teach children (in an attempt at ultra-refinement of correct pronunciation) to pronounce such a phrase as "at all" in such a way as to produce a faint guttural sound between the words. The speaker stated that this sound was an almost exact reproduction of a certain guttural occurring in the Arabian alphabet. On motion adjourned.

APRIL 20, 1911. — Adjourned meeting. Illustrated lecture, "Child Labor in Pennsylvania," by Fred. S. Hall, Secretary Pennsylvania Child Labor Association.

MINUTES OF SECTION A.

FEBRUARY 9, 1911.—The subject of the evening's discussion was "Linguistics," led by Henry L. Broomall.

FEBRUARY 16, 1911.—C. M. Broomall made some report on the progress of his research on the bacteriology of Media water. His remarks were illustrated by the exhibition of fermentation tubes and by blackboard tabulation of results.

MARCH 16, 1911.—Sanford Omensetter drew attention to recent arrivals among the feathered tribe. Under the microscope was shown a variety of objects, and interesting and profitable discussion followed.

MARCH 30, 1911.—C. M. Broomall, with blackboard illustration, discoursed upon the principles of parabolic, hyperbolic and elliptic reflection.

APRIL 13, 1911.—After a meeting of miscellaneous scientific nature it was proposed that the Section spend a portion of a day in field work. Definite action was postponed until next meeting.

APRIL 27, 1911.—After an interesting discussion on subjects of general interest it was decided to have an outing in the Middletown Barrens on the afternoon of Saturday, the 6th of May. All persons interested in the fauna, flora or geology of that region were invited to accompany the party.

INSTITUTE NOTES.

The lecture course during the past Winter has not been well attended. Indeed, the audiences at the meetings of Section A have been larger than at some of the formal lectures. Even the illustrated scientific lectures have lost their charm for the popular mind in Media since the advent of moving picture shows. In view of this it is very probable that the next Winter will not include a lecture course as part of the Winter's curriculum.

President T. Chalkley Palmer has recently returned from a trip to England and France. While abroad Mr. Palmer had the opportunity of making the acquaintance of a number of foreign scientific men and had many enjoyable meetings with them.

Arrangements are being made for an Institute Field Day in May. It is the intention to visit some points of local interest to botanists, geologists, mineralogists, etc., for the purpose of making collections. It has been the custom in the past to have excursions of this character each Summer.

It has been decided to continue weekly the meetings of Section A throughout the coming Summer. These meetings are full of interest for the members, and by unanimous consent it has been decided to take no "vacation." The officers of the Section deserve great credit for their successful management of its affairs.

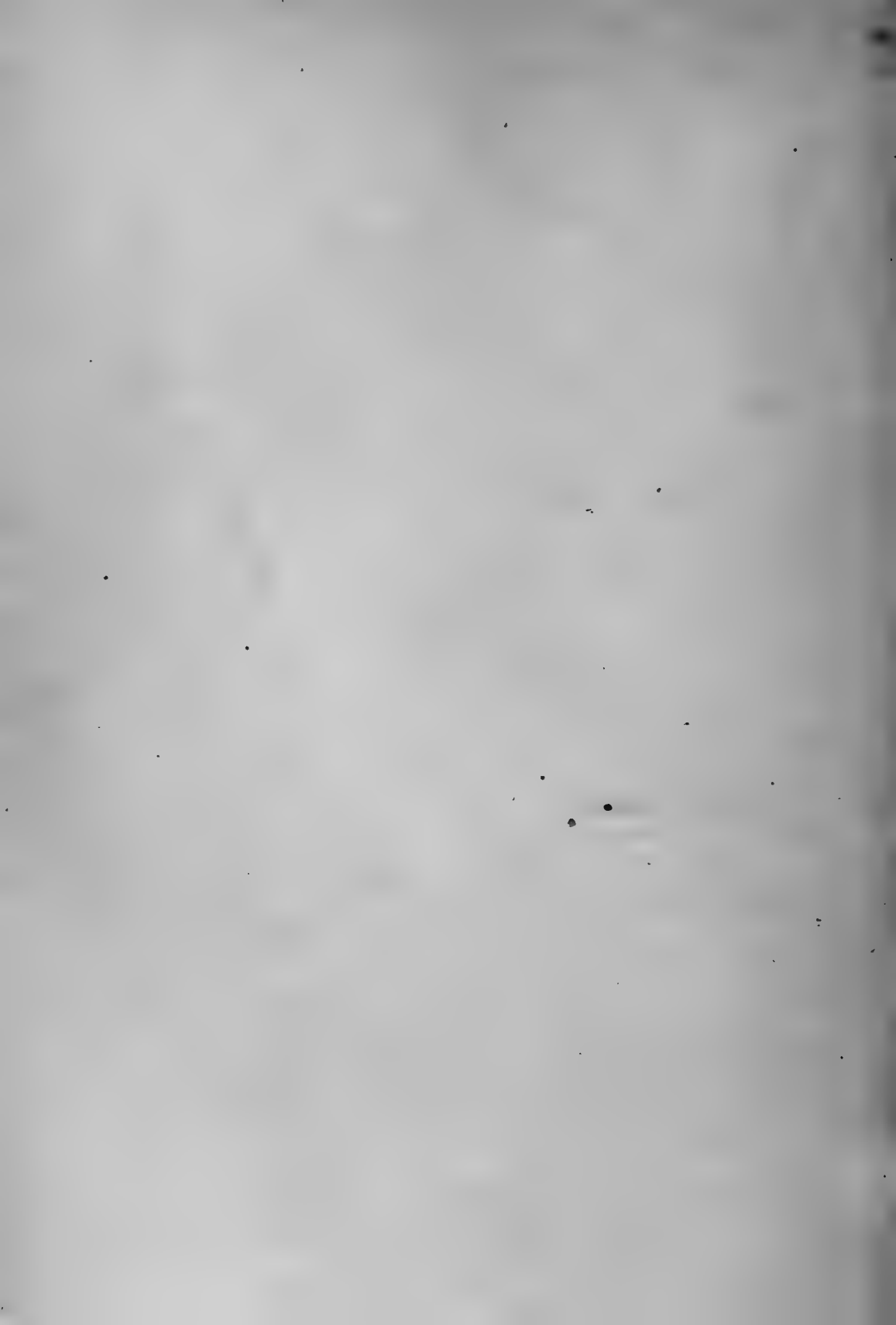
The eleventh edition of the "Encyclopædia Britannica," for which the Institute has subscribed, will be a fine addition to the library. In so far as possible, the attempt is made to keep the shelves supplied with the latest and best scientific literature.

OFFICERS OF THE INSTITUTE :

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July, 1911

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OF THE
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INSTITUTE OF SCIENCE

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PROCEEDINGS

OF THE

Delaware County Institute of Science

VOL. VI, No. 4

JULY, 1911

THE TRANSITION CURVE.

BY C. M. BROOMALL.

Of the various factors making for rapidity and safety of railway travel, the fundamental one is, of course, the track. The best mechanical construction in this regard is essential, and yet even with everything mechanically perfect the system remains far from satisfactory for high speed travel unless certain further conditions are complied with. There is still something lacking, namely, that certain group of refinements which may be classed under the term *alignment*. Alignment consists of perfect straightness of straight track, of easy curvature of curved track, of proper superelevation on curves, of the transition curve, etc. In short, alignment concerns the *geometry* of the track in contradistinction to its mere mechanical construction. Without this final touch of geometrical perfection comfort and safety in fast travel are impossible.

The railroad line in its simplest conception consists essentially of a series of straight stretches or tangents uniting a series of simple circular arcs. In this simple conception of the track one grave difficulty presents itself, and that is the impossibility of the train passing from the straight to the curved track, and vice versa, without dangerous or unpleasant shock. On curves it is necessary that the outer rail be elevated above the inner in order that the dangerous pressure due to centrifugal force against the outer rail may be offset by the attraction of gravitation tending to make the

tically. As far as concerns the mathematical proof, these weights may be represented by the single load W , as shown. If this load W is resolved into two components, one perpendicular and the other parallel to the slope from rail to rail, the former component may be neglected, as it is only the latter that opposes the centrifugal force. The centrifugal force acting horizontally in the direction of the arrow C is given in amount by the ordinary formula

$$C = \frac{MV^2}{R}$$

where M = mass, V = velocity and R = radius of track. C may now be resolved into its components, one perpendicular to the slope of the track, which component may be neglected, and the other parallel to the slope of the track, acting in opposition to the effect of gravity.

From similar triangles

$$\frac{T}{W} = \frac{e}{g}$$

where e = superelevation and g = gauge. Hence

$$T = \frac{We}{g} = \frac{32.2 Me}{g}$$

Again

$$\frac{C'}{C} = \frac{h}{g}$$

where h = AD. Therefore

$$C' = \frac{h}{g} C = \frac{h}{g} \frac{MV^2}{R}$$

Equating T and C',

$$\frac{32.2 \text{ Me}}{g} = \frac{h}{g} \frac{MV^2}{R}$$

$$32.2 e = h \frac{V^2}{R}$$

$$\therefore e = \frac{hV^2}{32.2 R} \dots\dots\dots (1)$$

For all practical purposes we may assume h as equal to the gauge, whence results

$$e = \frac{gV^2}{32.2 R} \dots\dots\dots (2)$$

which is the ordinary formula for the superelevation of the rail. It will be noticed that e varies directly with the square of the velocity and inversely as the radius of the curve. Since the velocity of the trains varies, it is impossible to have the superelevation correct under all circumstances. The best to be done is to substitute for V in formula (2) the average speed of fast trains over the given curve.

Returning now to the problem of passing from tangent to curve on the above assumed simple track, it is seen that theoretically at the point of curve the superelevation must jump instantaneously from $e = 0$ to $e = \frac{gV^2}{32.2 R}$. This being

impossible, some method must be devised for passing in a more gradual manner through this critical point.

There are two common methods in use for the solution of the difficulty, one of them being only a more or less successful makeshift, while the other method is both theoretically and practically a real solution of the problem.

The first method consists in starting to superelevate the track some distance in advance of the point of curve, so that when the wheels reach the curve all or nearly all the superele-

vation has been attained. A reverse process of "run-off" at the other end of the curve restores the original level condition of the rails. This method is a more or less successful practical solution of the difficulty and is used on many railroads.

It is probable that its simplicity in comparison with the supposed mathematical difficulties of the second method, rather than its practical success, does much to retain it in use. There are several grave objections to this run-off method which may be mentioned. In the first place, the gradual increase of superelevation produces an increasing pressure against the inner rail equal in amount, just before the wheels arrive at the point of curve, to that which the centrifugal force would produce on the given curve against the outer rail if no superelevation existed. The sudden cessation of this pressure as the wheels pass on the circular curve tends to produce a more or less unpleasant shock to the passenger. Again, the gradual tilting of the car approaching the curve is unpleasant when one's senses inform him that he is not moving in a curve, and that such a leaning to one side is not called for by the conditions of equilibrium of motion. Indeed, the same equations for balancing gravitation and centrifugal force apply to the passenger as he sits in his seat as apply to the car on the rails. At the other end of the curve, the point of tangency, the same objectionable effects occur in reversed order. As the wheels pass from circular motion to the straight track the car slides downhill against the inner rail and exerts a sudden pressure corresponding to the centrifugal force on the given curve, which force gets gradually less and less until the superelevation is entirely run off. The passenger will also pass through a corresponding series of unpleasant sensations.

The second method of solving the problem of passing from tangent to curve and curve to tangent is both theoretically and practically perfect. Its only objection is a certain supposed mathematical difficulty in connection with its theory and use. This ill repute arises probably from the cumbersome way in which the subject is set forth in many text

Assuming V as constant in equation (2) :

$$e = \frac{gV^2}{32.2 R}$$

it is seen that for various degrees of curvature the superelevation varies inversely as the radius, or what is the same thing, the superelevation varies directly as the curvature. Hence, in connecting the tangent $M'A$ with the circular curve BC by means of a transition curve we must adopt a form of transition curve such that the curvature and superelevation at all points maintain the relationship expressed by equation (2). Since the simplest and most natural thing is to have the superelevation increase uniformly from 0 to $\frac{gV^2}{32.2 R}$ it follows

that the logical form of transition curve to adopt is that curve whose curvature increases (and radius decreases) directly as the distance measured along the curve. Since the angular deviation of the transition curve from $M'AX$ is small, this condition may be expressed by the equation

$$\text{Curvature} = \frac{\frac{d^2y}{dl}}{\frac{dl}{dl}} = \frac{d^2y}{dl^2} = kl \quad \dots\dots (3)$$

$$\text{Integrating,} \quad \frac{dy}{dl} = \frac{kl^2}{2} + k_1$$

$$\text{Since } \frac{dy}{dl} = 0 \quad \text{when } l = 0, k_1 = 0;$$

$$\text{whence} \quad \frac{dy}{dl} = \frac{kl^2}{2} \quad \dots\dots\dots (4)$$

$$\text{Integrating again,} \quad y = \frac{kl^3}{6} + k_2$$

$$\text{and since } y = 0 \quad \text{when } l = 0, k_2 = 0;$$

whence, finally

$$y = \frac{kl^3}{6} \quad \dots\dots\dots (5)$$

which is the equation of the Transition Curve.

This curve, which satisfies the condition that the radius decreases and the superelevation increases in proportion to the length, is one in which the centrifugal force is always balanced by the inward pull of gravitation. In other words, the rails suffer no side pressure from the wheels.

To find the value of k , consider equation (3). There obtains for any point on the transition

$$kl = \frac{d^2y}{dl^2} = \frac{\frac{dy}{dl}}{dl} = \text{curvature} = \frac{\frac{dl}{R}}{dl} = \frac{1}{R}$$

At B this gives

$$kl_c = \frac{1}{R_c}$$

From which

$$k = \frac{1}{l_c R_c} \dots\dots\dots (6)$$

and therefore the equation of the transition curve becomes

$$y = \frac{l^3}{6 l_c R_c} \dots\dots\dots (7)$$

In order to make practical use of such a curve it is necessary to establish certain of its characteristics, as follows:—

(A) From equation (7) it is seen that the offsets from the tangent increase as the cube of the distance along the curve.

(B) From equation (4) it is evident that the sine of the angle $\left(\frac{dy}{dl}\right)$ between the tangent to the curve and the original tangent increases as the square of the distance along the curve. Since this angle is always small, its sine may be taken as approximately equal to the arc, so that the second characteristic may be stated as follows: That the angle

between the tangent to the curve and the main tangent increases as the square of the length of the curve.

(C) The curvature increases directly as the distance along the curve, this being as already shown the basic principle of the transition curve.

(D) The spiral angles to various points of the curve, being limited by the corresponding normals to the curve, increase as the square of the distance, as is evident from equation (4).

(E) The deflection angles at various points of the curve are approximately equal to one-third the corresponding spiral angles and therefore increase as the square of the distance. This can be shown thus : —

$$\sin \text{BAR} = \frac{\text{BR}}{\text{BA}} = \frac{kl_c^3}{6l_c} = \frac{kl_c^2}{6} \text{ (approximately)}$$

$$\sin \text{BNR} = \sin S_c = S_c = \frac{dy}{dl} = \frac{kl_c^2}{2} \text{ from (4), (approximately)}$$

$$\therefore \text{BAR} = \frac{S_c}{3} \text{ (approximately) } \dots\dots(8)$$

A similar argument applies to all points of the curve.

(F) The circular arc if produced backwards from B until it becomes parallel to AX will have a length equal to one-half the transition curve. Thus, from (4) and (6) there results for the angle of the tangent to the transition curve at B, approximately,

$$\frac{dy}{dl} = \sin S_c = S_c = \frac{kl_c^2}{2} = \frac{l_c^2}{2l_cR_c} = \frac{l_c}{2R_c}$$

Again, the angle of the tangent to the circular arc at B in terms of distance L_c from D is

$$S_c = \frac{L_c}{R_c}$$

But at B the circle and transition have common tangency, so that equating

$$\frac{L_c}{R_c} = \frac{l_c}{2 R_c}$$

and therefore

$$L_c = \frac{l_c}{2} \dots\dots\dots (9)$$

(G) The relationship between the transition curve and the circular curve with which it is to connect is expressed by the equations

$$S_c = \frac{l_c^2}{2 R_c} \quad \text{or} \quad R_c = \frac{l_c^2}{2 S_c} \dots\dots\dots (10)$$

This can be shown as follows: If a perpendicular is erected at the mid-point of the chord BD we have

$$\frac{BL}{R_c} = \sin \frac{S_c}{2} = \frac{S_c}{2} \quad (\text{approximately})$$

But $BL = \frac{l_c}{4}$ from (9), (approximately)

Whence

$$\frac{l_c}{4 R_c} = \frac{S_c}{2} \quad \text{and}$$

$$\therefore S_c = \frac{l_c^2}{2 R_c} \quad \text{or} \quad R_c = \frac{l_c^2}{2 S_c}$$

(H) Since the offsets increase as the cube of the distance and $AB = 2AE$ there results

$$EF = \frac{BR}{8} \dots\dots\dots (11)$$

$$[I] \quad DF = \frac{BR}{4} \dots\dots\dots (12)$$

For, by similar triangles

$$\frac{BK}{BD} = \frac{BD}{R_c}$$

$$\text{Hence } BK = \frac{BD^2}{2R_c} = \frac{l_c^2}{8R_c} = \frac{l_c^2}{\frac{8l_c}{2S_c}} = \frac{l_c S_c}{4}$$

$$\text{Again, } BR = AB \sin \frac{S_c}{3} = \frac{l_c S_c}{3} \quad (\text{approximately})$$

$$\text{Hence } \frac{BK}{BR} = \frac{\frac{1}{4}}{\frac{1}{3}} = \frac{3}{4}$$

$$\therefore BK = \frac{3BR}{4} \quad \text{and hence}$$

$$DF = \frac{BR}{4}$$

(J) From (11) and (12) it is evident that $EF = \frac{DF}{2}$ or that E is the mid-point of DF.

With the foregoing characteristics in mind the laying out of the curve becomes a simple matter. The problem as usually met with will be the following: Given the intersection angle I, the radius R_c of the circular curve and the length l_c of the transition curve, to locate the complete curve, that is, the central circular curve and the transition curves at each end. Both for simplicity and also to obtain more accurate results it is preferable to run the first transition from A to B and then the second transition from A' back to B' and then run in the circular curve between these points with transit at B or B'.

The first step, therefore, is to calculate the total tangent AX. This is made up of three parts, as follows:

$$T = AF + DS + MX \quad \text{or}$$

$$T = \frac{l_c}{2} \cos \left(\frac{1}{4} \cdot \frac{S_c}{3} \right) + R_c \tan \frac{I}{2} + MS \tan \frac{I}{2}$$

Since $MS = \frac{BR}{4}$ and $AF = AE$ approximately

$$T = \frac{l_c}{2} + R_c \tan \frac{I}{2} + \frac{l_c \sin \frac{S_c}{3}}{4} \tan \frac{I}{2} \quad \text{or}$$

$$T = \frac{l_c}{2} + R_c \tan \frac{I}{2} + \frac{l_c S_c}{12} \tan \frac{I}{2} \quad (\text{approximately})$$

Whence, by (10)

$$T = \frac{l_c}{2} + R_c \tan \frac{I}{2} + \frac{l_c^2}{24R_c} \tan \frac{I}{2} \dots\dots\dots (13)$$

This formula makes it possible to locate A and A', and the field work is now easy. With the transit at A and A' lay out the two transition curves, working toward the central curve in each case. The ten deflections for the ten chords assumed for AB and A'B' will be

$$d_1 = .1^2 \times \frac{S_c}{3}$$

$$d_2 = .2^2 \times \frac{S_c}{3}$$

$$d_3 = .3^2 \times \frac{S_c}{3} \quad \text{etc.}$$

the value of S_c expressed in radians, being found from equation (10). After having located the two transition curves a circular curve is run in between B and B' in the usual way. To locate the instrument in the direction of the common tangent at the point of central curve B or B', set up, for example, at B, sight on A with inverted telescope and turn off the

angle $ABN = \frac{2}{3}S_c$ (since $ABN + BAN = BNR = S_c$) and revert telescope. The transit is now in position to run in the circular curve.

With the proper superelevation for the central curve and with this superelevation running off uniformly on each transition, the complete curve laid out as described will be the desired transition curve. At all points the curvature and superelevation are in constant ratio and gravitational pull inwards and centrifugal force outwards are balanced. Hence, theoretically, and to a large extent practically, the rails will suffer no side pressure from a train moving at the velocity for which the maximum superelevation has been figured.

CORRECTION: In the figure on page 142 the upper C should be C'.

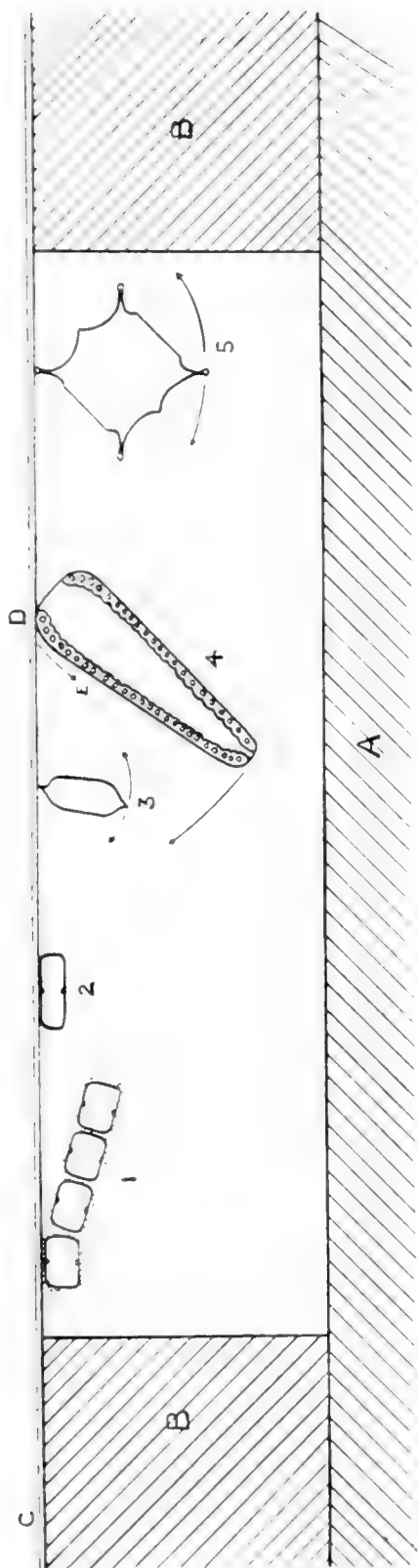
FURTHER NOTES ON DIATOM LOCOMOTION.

BY T. CHALKLEY PALMER.

In a former communication* concerning *Navicula socialis* I mentioned the ability of that diatom to crawl upon vertical surfaces and even to cling to and move upon the under side of a cover glass. It has also been implied that other species of diatoms may move in this position. I propose here to note some of the rather curious and unexpected circumstances observed in this connection, believing that any data of this sort cannot be quite valueless so long as authoritative writers continue to say that the motion of diatoms is not yet understood.

Anyone who is in the habit of collecting and retaining bottles of water containing diatoms will soon have occasion to note that the motile forms crawl up the sides of the bottles, especially on that side which is best lighted. Within a day's time the walls of the bottle will often be colored a dark amber, and by careful management one may get enough of the deposit under the microscope to show its composition. Most of the naviculoid forms, and many others, will so expand upon the vertical surface against the influence of gravity. Having pondered upon this phenomenon, I thought to give a more difficult task to these diatoms. A fresh gathering of *Navicula Iridis* was put into a conical Erlenmeyer flask and washed carefully into a thin layer on the flat bottom. The flask was then covered completely with black paper and capped with a thimble of tinfoil. A little window was cut in the black paper, about two inches above the bottom, and almost on a level with the top of the water. The flask was then left undisturbed for ten days, exposed to the diffused daylight from a northwest window. At the end of this time the paper was carefully removed, and a square patch, of a dark amber color, was found upon the wall of the

* PROCEEDINGS, Vol. VI, p. 118.



flask at the place where the little opening in the paper had been. This deposit was found to consist of quite pure *N. Iridis*. Under proper precautions the water of the flask was examined and no diatoms were found freely floating. The walls elsewhere were lightly strewn with frustules, driven by light-hunger up the overhanging, conical walls of the flask to the little ray of light in the darkness.

If the diatoms are capable of so much, why should they not succeed in moving perfectly well upon the under surface of the cover glass? It is only one step farther. To test the matter for various species, I made use of a very shallow cell. This cell is constructed of two parallel strips of thin glass, cemented upon an ordinary glass slip. The cover glass rests upon these two strips, and the cell is open on two sides and so shallow that a $\frac{1}{5}$ inch objective will readily focus down to the bottom. A diagram of a section of the cell is given opposite, A being the glass slip, B B the two thin strips (greatly exaggerated in relation to thickness) and C the cover glass. In order to use the cell for the present purpose, the diatoms to be observed are dropped in with enough water to fill the space, the cover glass is placed, and the whole arrangement reversed so that the cover glass is underneath and the slip above. As soon as the diatoms have settled, the cell is brought carefully into normal position with C on top. Many frustules will be found clinging to the under surface, and soon they will begin to move.

Navicula Iridis is represented in median cross-section at 2 in the diagram. This diatom, unlike many of its genus, has a very thin coleoderm, so that the rather flat surface of the valve near the middle of the length appears to be in close contact with the glass. The raphe and the central nodule are slightly below the general beaded surface, but the former is still almost in contact. Toward the pointed ends, the surface curves slightly downward, like the keel of a flat-bottomed boat at bow and stern. In addition to the position illustrated, where mere "adhesion" between the flat valve and

the glass may play its part, this diatom can also retain its hold when one end sinks down somewhat, so that the longer axis makes an acute angle with the glass. In India ink emulsion, minute particles of the ink follow down the raphe to the contact nodule, at which point they collect in the slight depression and are finally squeezed out to the side of the valve in the form of a small, irregular mass, evidently cemented with slime. At the same time (and this is most unexpected) a similar stream, but not so pronounced, runs from the after end of the valve to the central nodule, *in the direction of the motion of the diatom*, and the ink particles so arriving help to form the little masses already described. This stream would appear, on careful focussing, not to be in quite such close contact with the glass as that coming from the front end. At times the diatom comes almost to rest, there is evidence of a struggle, and with a sudden jerk the crawling proceeds. We have here to do with a sticking fast to the glass and a rupture of the slime which is giving the trouble. This diatom crawls rapidly and surely, and is able to push loose other species not so securely applied to the glass by broad surfaces. Yet if by any means it entirely loses control it sinks through the water at once, and falls upon the bottom of the cell. It is too small a form to promise much light on the problem of motile mechanism. But so far as one is able to see, the phenomena described are quite well reconcilable with the general view that a stream of protoplasm along the raphe is the actuating element.

Navicula socialis. Although this diatom is described as occurring in flat, tabular groups of four frustules, frequently groups are seen in end view to be slightly curved. Sometimes, also, one frustule of a group will be bent out of the plane of the other three, even to the extent of 90° . A less pronounced example of this last condition is represented at 1 in the diagram, the view being a median cross-section of the group. These aggregations are surrounded by a common nimbus of coleoderm, and the contact with the cover glass is

therefore less close than that described for *N. Iridis*. But alike when the groups are flat and when they are as here indicated, the diatoms have no special trouble in retaining their dependent position, and they move about under the cover glass approximately as well as when upon the slide. When, however, the last raphe is by any means caused to part company with the glass, the whole group falls down through the water. The tenacity with which these diatoms cling may be understood on considering this diagram of a group of four held in place by only one of the number. No facts of interest were gathered from behavior in ink emulsion.

Nitzschia linearis. This is roughly and inaccurately represented in cross section at 3. The small keels of this diatom are curved in reverse directions, and each ends in a very thin edge, where runs a raphe or cleft from end to end. Being very long, very narrow, and unusually flat besides, one is left to wonder how it manages to crawl so vigorously and so continuously on a flat surface, if it be necessary that a raphe shall always be in contact with the substratum. However this may be, *N. linearis* is one of the most able of all at crawling when suspended by one raphe from the under side of the cover glass. As it goes, it sways from side to side, swinging as on a hinge, in the directions indicated by the arrows. Hanging clear, held only by this knife-edged keel, it goes ahead rapidly and jostles loose other diatoms larger than itself. There is not a sign of anything to explain the basis and means of these amazing activities, which meantime continue with every aspect of a complete competence for an indefinite number of repetitions.

Surirella linearis and *S. splendida*. Both these species suspend themselves upon the under side of the cover glass, and move about very freely. The schematic figure 4 represents a longitudinal view of a *Surirella* in an extreme position, with only one end of a keel in contact. It does no crawling in this attitude, but by some sleight it will raise the lower end gradually in the direction of the arrow until a con-

siderable portion of the keel is applied to the glass. Then it begins moving. Sometimes it will go straight along, hanging by one keel only, as in the cross-section diagram 5. It is accustomed to swing more or less as indicated by the arrows, somewhat as does the *Nitzschia*. At other times it will swing so far that two raphes are applied to the glass at the same time. As a rule, it hangs dangling down as in the figure, with a slight tendency to roll sidewise just as when upon a substratum—in both cases following the curve of the keel. All these gyrations seem to me best explained by the view that they are due to a minute ribbon of contractile protoplasm reaching through the narrow raphe in the keel, adhering to the glass, and moving back and forth along the length of the raphe. In figure 4, on this view, there would be a firm but very short contact at D. The protoplasm forming this contact begins to move along the raphe in the direction of E, retaining its grip upon the glass. The result would be a smooth sliding of the frustule upon its keel in the opposite direction, until the lower end gradually rises and a longer section of the raphe comes into reach of the glass. Then, if the current continues, motion of translation along the glass will be the result, and this motion will continue so long as the current endures, and the grip of any portion of the protruding plasma remains good. The transverse swaying motion is also capable of explanation on the same lines, but not of elucidation by diagrams on a flat surface.

Having vouched for the reality and the substantial accuracy of these facts, I would once more remark upon the impossible character of any general theory of diatom motion based on inward or outward streams of gas, water or *gallerte*, and express a renewed and greatly reënforced conviction that moving protoplasm is the real and direct activator. Clinging and motion under such precarious conditions are of the very type of the wierd doings of protoplasm. We see the like in the rhizopods particularly, where the possession of the power to leave the slide and draw up to and crawl on the

under side of the cover marks at once the great gulf lying between these lowly creatures and even the most subtle microscopic foam of the wise Bütschli. And in the rhizopod, whether naked or hampered by a carapace, anyone may easily see the thing done before his own eyes by actual contact and movement of the living substance. Actually to see the propelling protoplasm in the living diatom is not so easy, and almost always it is quite impossible.* Heavily housed in silica, it streams mostly within ingenious and complicated tubes and minute clefts, protruding when necessary only slightly, and in thinnest threads or sheets that are so hyaline as to be invisible in water with the ordinary arrangements of lenses and illuminators.

The analogy with the rhizopods need not be pushed too far. In one respect there may seem to be a contrast so complete as to render the comparison of no value. The amœba moves in the direction of its general flow, while the diatom, by hypothesis, goes in the opposite direction to the flow of its protoplasmic streams. But even so, the difference is not so great as might at first appear, since while the interior currents of the amœba move forward, the peripheral currents next the substratum on which it rests, move backward just as does the stream in the raphe of the *Navicula* or the *Surirella*. The contrast is not in this respect so violent after all. But certainly the methods of motion in the two cases are unlike in important respects, for the amœba rolls about vaguely by means of a continuous succession of bodily deformations, impossible to the rigidly confined diatom, which must push all its heterogenous apparatus by specialized surface-layers. And these layers and threads, unlike the surfaces of the amœba, continually bathe themselves in a thin secretion of "gallerte," sufficiently adhesive to afford a basis for a real

* In the "Journal of the Royal Microscopical Society" for June, 1912, an account is given of a *Coscinodiscus* exhibited by Mr. Siddall, showing pseudopodial protrusions with dark-ground illumination.

push. In this sense the gallerte does certainly contribute to diatom motion ; and so one comes at last to see how the facts of Lauterborn, as distinguished from his deductions, may fit perfectly into a view of the mechanism of diatom motion which will reconcile all the phenomena—even such as have to do with the capacity to crawl upon an overhead surface.

DELAWARE COUNTY INSTITUTE OF SCIENCE
MUSEUM CATALOGUE.

SECTION : ANTHROPOLOGY. DEPARTMENT : AMERICA.

1. Cast labeled "Cast of the Sculptured Double Serpent found in a mound at Chillicothe, Ohio." The original was found in a large earthwork on the North Fork of Paint Creek, Ross County, Ohio, described in "Smithsonian Contributions to Knowledge," Volume I, page 26. The material of the original is a fine, cinnamon colored sandstone. The specimen is supposed to represent a coiled rattlesnake. It has two faces identical in sculpture except that one is plane and the other slightly convex (hence the cast in the museum represents only half the original). The head of the original sculpture was broken by the finder and lost, but it is reported that the head was surrounded by feathers. The serpent entered widely into the superstitions of the American nations. Whenever it appears, whether among the Natchez, the Aztecs or the temples of Central America, it is invariably the rattlesnake. The feather headed rattlesnake was in Mexico the peculiar symbol of Tezcatlipoca, otherwise symbolized as the sun.

2. Seven plaster casts. The exact counterpart of one of these is described in "Smithsonian Contributions to Knowledge," Volume I, page 247, as being a sculpture in porphyry found in Ohio near Chillicothe. It is to be presumed from this and a general similarity of the other casts with those depicted therein, that the entire seven casts represent specimens from Ohio. On the other hand, in the minutes of the Institute of October 7th, 1882, there occurs mention of a donation by Mrs. William H. Miller, of Media, of a "box of casts of Peruvian pottery." Although there is nothing in the museum at all approaching the description of this donation except the casts referred to, yet the balance of testimony

seems to indicate Ohio as the location, the supposition being that Mrs. Miller's donation has been mislaid in some way.

3. Cast of tablet found in an old mound situated in the western part of the city of Cincinnati, together with a skeleton and two pointed bones. The relic is in the possession of Erasmus Gest, Esq. A full account of it can be found in "Smithsonian Contributions to Knowledge," Volume I, page 274.

The original is composed of a fine grained, compact sandstone of a light brown color. The markings are the subject of doubt; they may be hieroglyphic, but it is suggested that they may represent the leaves and stalk of a plant. It is also suggested that it may be of astronomical origin. Its resemblance to an Egyptian *cartouch* is to be noticed. Another suggestion of its purpose is that it is a *stamp* used for impressing ornaments on clothes or skins, similar to the burnt clay ones found in Mexico and the Mississippi mounds.

4. Two Inca skulls, presented by Dr. Isaac T. Coates. These skulls show every evidence of antiquity.

5. Three Peruvian (?) images. No data in minutes.

6. Piece of Aztec pottery labeled:

"Aztec pottery from the 'Mound of Sacrificios' near Vera Cruz. This piece of pottery was made before Cortez landed in America. This along with other relics was dug up by Chief Engineer Melville in 1867, then serving aboard the U. S. Ship _____ and stationed near Vera Cruz during the French occupation of Mexico.

GEO. W. MELVILLE,
Chief Engr., U. S. N."

7. Cast labeled: "Cast of an ear of Indian corn found inside of the envelope of a Peruvian mummy. Presented by P. A. Brown.

In the minutes of January 5th, 1839, this is mentioned as a cast of Indian corn found in the envelope of a *Mexican* mummy.

The label quoted above appears to be in the handwriting of the donor and signed by him. This, together with the fact that embalming seems not to have been so common in Mexico as in Peru, would indicate that the original label is correct.

8. Local find of Indian relics from along the river front at Chester, presented by T. Chalkley Palmer. These comprise finished, unfinished and broken arrow heads, pottery, scraper, axes, gorget, etc. This is a remarkable find and a full account of these is given in Volume I, Number 2, of the PROCEEDINGS.

9. Box of twenty pieces of glazed pottery presented by E. A. Barber, of West Chester (see minutes of Institute of October 7th, 1876). These were collected by him while with Hayden's exploring party, in the ancient ruins of Colorado. For illustrations of ancient Indian pottery from Colorado see "Explorations for Railroad Route from the Mississippi to the Pacific," Volume III, page 48.

10. Box of fifteen pieces of ancient pottery from the shell mounds of Florida. Collected and presented by Samuel L. Anderson. Presumably these are from St. John's, as per Institute minutes of August 7th, 1880.

11. Pipe made by the Minnesota Indians. Presented by Edward A. Price, Esq., of Media.

12. Model of birch canoe from the lower St. Lawrence River. Presented by Edward A. Price, Esq., of Media, Pa.

13. An Indian pipe presented by Dr. William Young, of Chichester, Delaware County, Pa. This pipe was given to

Dr. Young by Major Pilcher, U. S. A. It was the property of the celebrated Indian chief Black Hawk and was smoked by President Van Buren when Black Hawk was on a visit to Washington in 1834.

14. Indian mortar found on the lands of James J. Brooke, Haverford, Delaware County, Pa. Presented by George Labby, of Media, Pa.

15. Indian implement from Romney, West Virginia. Presented by J. H. Hollingsworth, of Nether Providence, Delaware County, Pa.

16. Indian implement from Westtown, Chester County, Pa. Presented by J. H. Hollingsworth, of Nether Providence, Delaware County, Pa.

17. Indian implement from Romney, West Virginia. Presented by J. H. Hollingsworth, of Nether Providence, Delaware County, Pa.

18. Indian implement from Burlington County, N. J.

19. Two pairs of Indian moccasins. Presented by Mrs. William H. Miller, of Media, Pa.

20. Box of twenty-four arrow heads, presented by Dr. J. T. Huddleson. Presumably found in Delaware County.

21. Indian implement, supposed to have been used for opening oysters, found on a shell island in Hernando County, Florida. Presented by Colonel Joseph Wilcox, of Philadelphia, Pa.

22. Indian axe from Concord, Delaware County, Pa. Presented by Nathaniel Walter.

23. Indian axe presented by Dr. George Smith, of Upper Darby, Pa.

24. Large Indian axe presented by Jonathan Pyle, of Haverford Township, Delaware County, Pa.

25. Indian pipe.

26. Indian relic from Romney, West Virginia. Presented by J. H. Hollingsworth, of Nether Providence, Delaware County, Pa.

27. Box of twelve Indian arrow heads found in Haverford Township, Delaware County, Pa., by Elias B. Eckfeldt. Presented by Adam C. Eckfeldt.

28. Birch bark cap made by Winnebago Indians. Presented by Dr. W. T. W. Dickeson, of Media. The Winnebagoes were the inhabitants of the western shore of Lake Michigan. They were a tribe of the Dakota (Sioux) stock of Indians. (See "American Races," Brinton, page 98).

29. A tomahawk used in Braddock's defeat. Presented by William Sloan, of Media.

30. Scraper, bone or horn. Presented by Lieutenant Commander H. DeHaven Manley, July 6th, 1872, who says: "It was given to me at Montevideo without explanation, and I know nothing of its history nor from whence it came." Scrapers similar to this were in use among the North American Indians. In the "Annual Report of the United States National Museum, 1889," Plate XCL, will be found a drawing of such a scraper, which is almost an exact counterpart of the one in the Institute collection.

31. Skull found in Springfield Township, Delaware County, Pa., under the roots of a large tree. Supposed to be Indian. No data.

32. An Indian axe found in Upper Darby, Delaware County, Pa. 1831.

33. An Indian axe from Gloucester County, New Jersey.

34. Three boxes of arrow heads. Presented by Dr. Huddleson.

35. Spear head presented by Joseph Conrad.

36. Mexican saddle presented by C. Gillen. 1870.

37. Hat made by Indians, near Kenai, up Cook's Inlet, to the north of the Straits of Chelekoff. Presented by Mrs. W. H. Miller, of Media, Pa.

38. Collection of several hundred arrow heads, supposed to be mainly local, presented by Isaac Worrall, Sr., of Media.

Also miscellaneous lot of arrow heads, axes, mortars, etc., of which no data can be found. Supposed to be of local origin.

FIELD DAY OF SECTION A.

On the afternoon of Saturday, the 6th of May, a number of those interested in out-door science spent a profitable time in the Middletown Barrens. Under the auspices of Section A some two dozen persons trolleyed to the vicinity of Honeycomb Church, whence the route skirted the banks of Dismal Run past Pink Hill (now much denuded of its treasured *Phlox subulata*), to Trout Run. After a short rest the Barren woods were explored and the banks of Crum Creek followed to Red Bridge, ending in a detour over the hills to Media. The geology of the serpentine district was a fruitful source of investigation, while an attempt to make a partial list of plants in flower yielded the following result : —

Taraxacum Taraxacum. Common Dandelion. Blowball
Saxifraga Virginiensis. Early Saxifrage
Houstonia cœrulea. Bluets. Innocence
Viola rotundifolia. Round Leaved Violet
Cornus florida. Flowering Dogwood
Fragaria Virginiana. Wild Strawberry
Comptonia peregrina. Sweet Fern
Potentilla Canadensis. Common Cinquefoil. Five Finger
Vaccinium stamineum. Squaw Huckleberry. Deerberry. Buckberry
Cerastrium arvense. Field Chickweed
Phlox subulata. Ground or Moss Pink
Viola sagittata. Arrow Leaved Violet
Alsine media. Common Chickweed
Claytonia Virginica. Spring Beauty
Viola Labradorica. American Dog Violet
Viola Canadensis. Canada Violet
Prunus Americana. Wild Plum
Arisæma triphyllum. Jack in the Pulpit. Indian Turnip
Chelidonium majus. Celandine
Dentaria laciniata. Toothwort
Anemone quinquefolia. Windflower
Sanguinaria Canadensis. Bloodroot
Asarum Canadense. Wild Ginger
Trientalis Americana. Star Flower
Cardamine bulbosa. Bulbous Cress

Barbarea Barbarea. Yellow Rocket or Cress

Equisetum (sp.) Horsetail

Bicuculla Cucullaria. Dutchman's Breeches. Soldier's Cap

Glechoma hederacea. Ground Ivy. Gill over the Ground

Polemonium reptans. Greek Valerian

Mitella diphylla. Mitrewort

Erythronium Americanum. Dog Tooth Violet

Muscari botryoides. Grape Hyacinth

Oxalis stricta. Upright Yellow Wood Sorrel

Viola villosa. Southern Wood Violet

Panax trifolium. Dwarf Ginseng

Azalea nudifolia. Purple Azalea. Wild Honeysuckle

MINUTES OF THE INSTITUTE.

MAY 4, 1911. — Annual meeting of the Institute, President T. Chalkley Palmer in the chair. Reports of committees and Curators and current business. On motion it was directed that the proper officials be authorized to purchase the eleventh edition of the "Encyclopædia Britannica" for the library. The following officers for the ensuing year were unanimously elected: —

President, T. Chalkley Palmer
First Vice President, Henry L. Broomall
Second Vice President, C. Edgar Ogden
Secretary, Dr. Benjamin M. Underhill
Treasurer, Carolus M. Broomall
Librarian, Henrietta K. Broomall
Curators, Homer E. Hoopes and Albert S. Barker
Publication Committee, T. Chalkley Palmer, Henry L. Broomall, Dr. Trimble Pratt, Dr. J. C. Starbuck and Dr. B. M. Underhill

A number of additions to the library were reported, including "The Handbook of American Indians," published by the United States Ethnological Bureau. Under scientific business C. M. Broomall exhibited some cultures of *Bacillus coli communis*, originating from inoculations with Media tap water. C. Edgar Ogden reported the proceedings in connection with a recent outing of the Geological Section of the Academy of Natural Sciences, in Chester County. After a lengthy discussion of geological topics in general the meeting adjourned.

JUNE 1, 1911. — Regular monthly meeting, with President T. Chalkley Palmer in the chair. Reports of committees and Curators and regular current business. Under scientific matters, A. W. Moon exhibited a beautiful specimen of a geode from Indiana. C. M. Broomall exhibited some pecu-

liar moulds under process of culture. President Palmer gave an account of observations made on the suspension of *Hydra* and other organisms on the under side of the surface of the water in which they live. C. M. Broomall gave an example of a method of multiplication used by the Russian peasants, recently brought to his attention. After general scientific discussion the meeting adjourned.

JULY 6, 1911.—Regular monthly meeting, with President T. Chalkley Palmer in the chair. Reports of committees and usual current business. A number of additions to the library were announced, covering geological and hydrographic topics. On motion a committee was appointed to consider and report upon the desirability of installing a hot water heating plant in the hall. In view of the heavy expense the Institute would be under if this matter were consummated, a number of methods for cutting down expenses were discussed. Under scientific business A. S. Barker exhibited a species of *Mycetozoa* gathered in Ridley Creek. C. Edgar Ogden and Sanford Omensetter spoke of the annoyance to which our native birds are subjected by the English sparrow. Mr. Ogden also spoke of the habit of this sparrow of destroying sprouting peas. C. M. Broomall reported the results of the bacteriological examination of Media tap water. R. J. Baldwin presented a specimen of trilobite from Perry County, this State. T. Chalkley Palmer exhibited a German mount of butterfly wing scales arranged to represent a rural scene. The President also spoke of the actions of a pet hermit crab in his possession. On motion adjourned.

MINUTES OF SECTION A.

MAY 11, 1911.—Albert S. Barker spoke on "Polarization of Light," illustrated by diagrams and apparatus.

MAY 18, 1911.—C. Edgar Ogden showed an Indian implement of trap, probably used for polishing, from Black Horse hill; also a very fine arrow head of clear flint from Swarthmore. C. M. Broomall reported that his bacterial investigation of Media water showed improvement in quality. Sanford Omensetter announced the appearance of red rust on berry plants and the advent of night flying moths.

MAY 25, 1911.—T. Chalkley Palmer by blackboard diagrams illustrated the mechanism of motion in diatoms. Sanford Omensetter exhibited specimens of *Drosera*. C. M. Broomall remarked upon the bacterial purity of Media water the past few weeks. He also spoke of the alternations of shape assumed by drops in falling from a faucet.

JUNE 8, 1911.—Address, "Photometry," by Dr. Harold C. Barker, illustrated by apparatus and formulas.

JUNE 15, 1911.—T. Chalkley Palmer spoke on *Navicula socialis*, illustrated by blackboard diagrams, and advanced the hypothesis that the groups of four in that species originate in a tetraspore. C. Edgar Ogden gave an account of the geology of a recent trip to Reading, Pa. In answer to a newspaper statement that seventeen year locusts were due this year, Sanford Omensetter replied that they could not be expected for eight years yet. C. M. Broomall by blackboard illustration controverted the theory of the constant tendency of cooling materials to crystallize in six sided figures. A. S. Barker spoke of having at one time seen globular lightning.

JUNE 22, 1911.—Sanford Omensetter reported the advent

of the Sphex insect. C. M. Broomall discoursed on the bacteriological condition of Media water since recent rains. Albert S. Barker explained the model of a star finder.

JUNE 29, 1911. — Address, "Orthographic Elision," by Henry L. Broomall.

JULY 13, 1911. — C. Edgar Ogden exhibited a tarantula and its nest. Dr. Trimble Pratt showed beach specimens (*Sertularia* and others) from Nantucket Island.

JULY 20, 1911. — C. M. Broomall explained by diagram the tendency of the top to rise. Albert S. Barker exhibited under the microscope a Tubularian from Bermuda.

JULY 27, 1911. — T. Chalkley Palmer illustrated the principle of floral atavism by means of specimens of *Rudbeckia hirta* and *Daucus carota*. A bunch of the former showed green bracts instead of yellow petals. Mr. Palmer also exhibited a specimen of hermit crab from Port de Paix, Hayti. C. M. Broomall reported progress in bacteriological determinations, and Alice Haviland gave an account of the actions of *Microhydra*.

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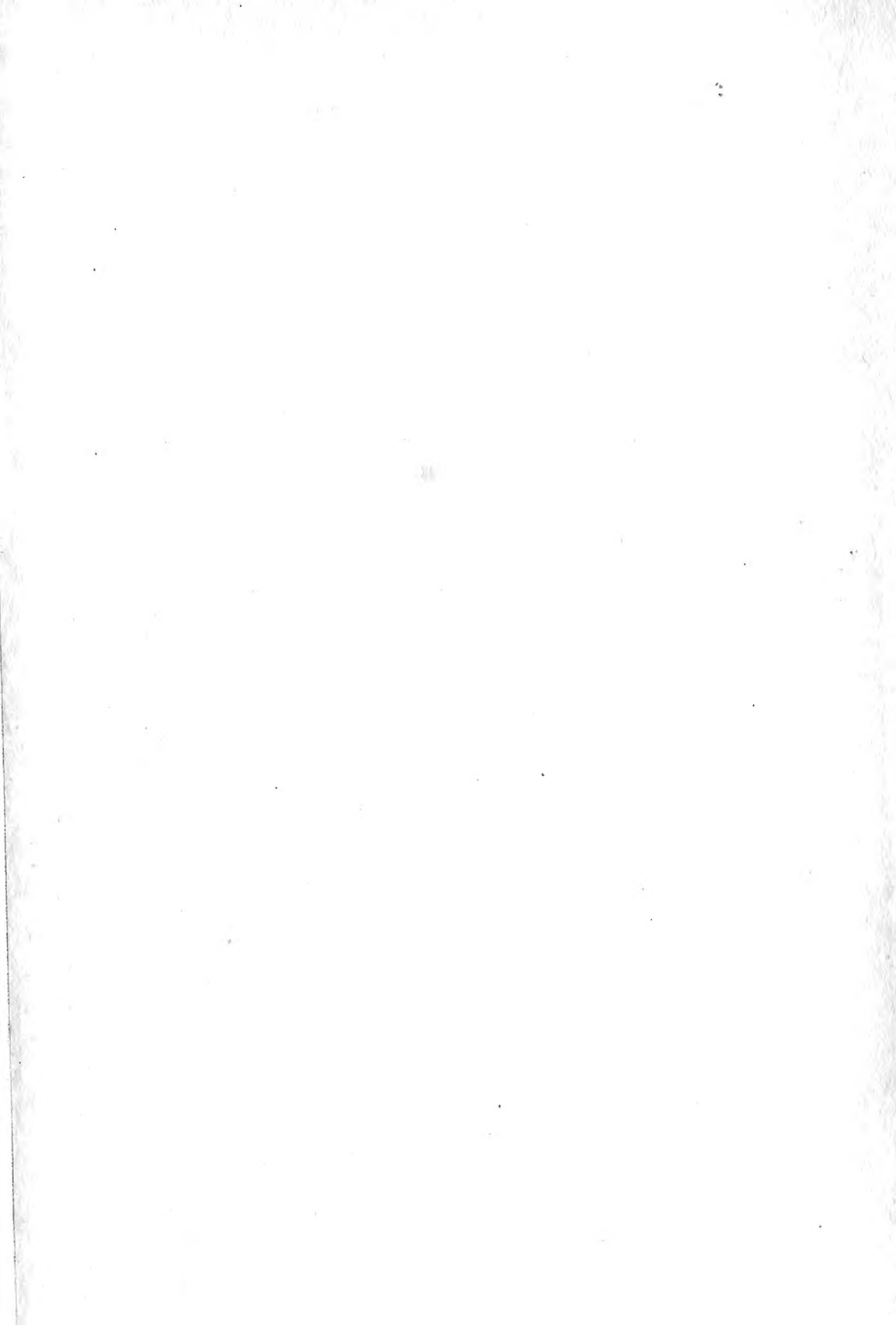
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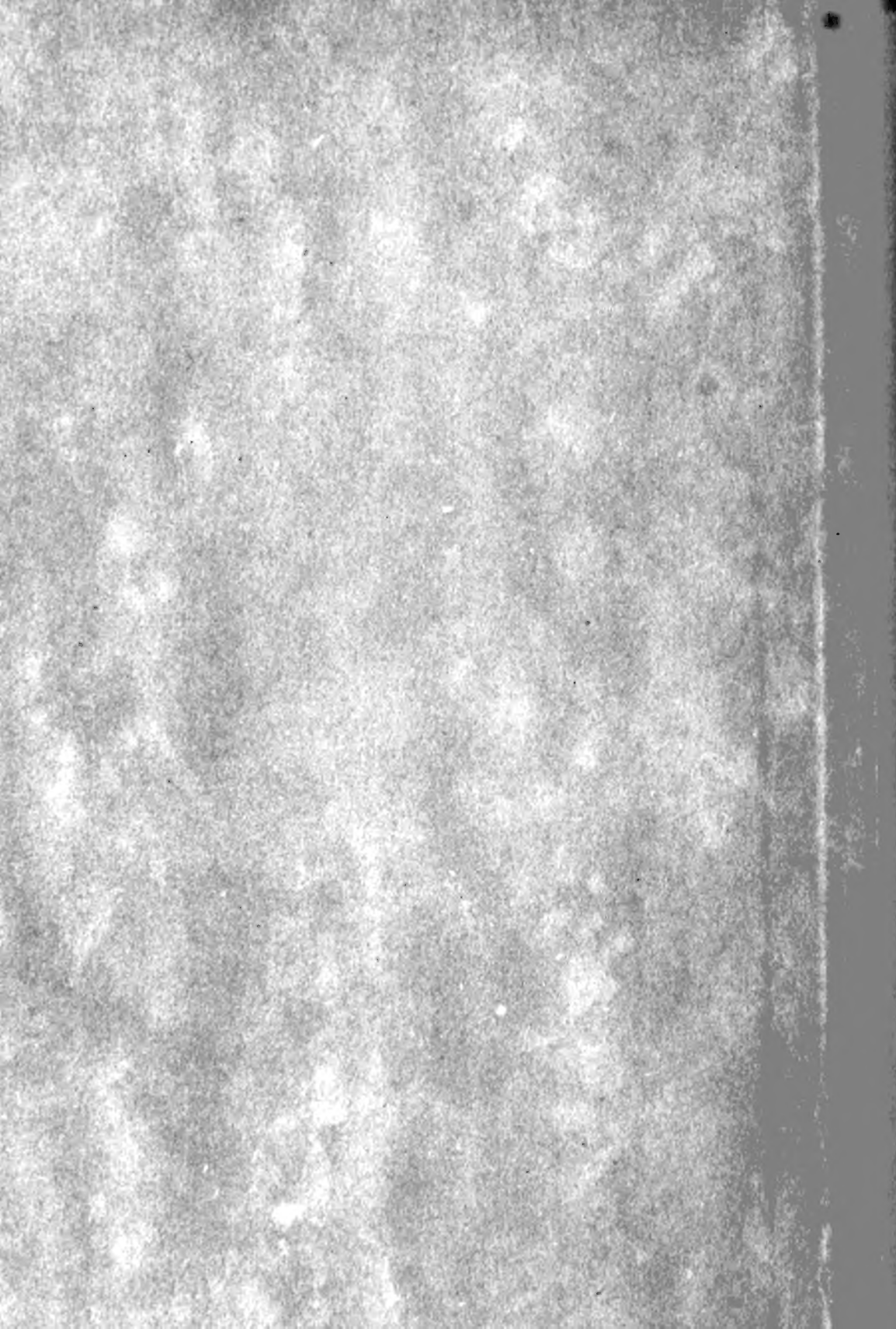
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